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Children's elevated cortisol levels at daycare: A review and meta-analysis

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Abstract

We reviewed nine studies in which children's cortisol levels at center daycare were assessed. Our first hypothesis, concerning intraindividual differences in cortisol levels across home and daycare settings, was also tested in a meta-analysis. Our main finding was that at daycare children display higher cortisol levels compared to the home setting. Diurnal patterns revealed significant increases from morning to afternoon, but at daycare only. The combined effect size for seven pertinent studies ($n = 303$) was $r = .18$ (CI .06–.29, $p = .003$). We examined all papers on possible associations between cortisol levels and quality of care, and the influences of age, gender, and children's temperament. Age appeared to be the most significant moderator of this relation. It was shown that the effect of daycare attendance on cortisol excretion was especially notable in children younger than 36 months. We speculate that children in center daycare show elevated cortisol levels because of their stressful interactions in a group setting.

Keywords: Cortisol; Stress; Center daycare; Review; Meta-analysis

Full-day childcare in a group-setting may elicit not only positive challenges for children (e.g., the development of cognitive and social skills), but may also provoke the strains and stresses of group life separate from the parents. Although process quality – usually described as what children actually experience in childcare – has been accepted worldwide as a core element of childcare quality, few studies have addressed children's well-being, stress, and emotional reactions in the specific context of center daycare. Stress responses during daycare may be triggered because a peer group for very young children is a demanding context that involves frequent emotional arousal. Also, the long hours, the separation of the parents and the need to reorganize security seeking behavior around multiple adults have been recognized as possible causes of stress (Dettling, Gunnar, & Donzella, 1999). One of the few studies that examined toddler's distress in a daycare setting was performed by Lamb and Zakhireh (1997). During an observation period of 20 h, 345 distress incidents were observed, from which almost half were ignored by peers.

Because observed behaviors do not always reflect the child's stress level reliably, researchers started to use physiological measures, in particular cortisol measures, to asses the child's stress responses in daycare. Cortisol is the primary hormonal product of the hypothalamic–pituitary–adrenocortical (HPA) axis, which is involved in complex biological processes implicated in the regulation of stress and emotions. The assessment of cortisol in saliva has proven to be a valid and reliable method (Kirschbaum & Hellhammer, 1994), and in general, increases in salivary cortisol levels are

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used as biological markers of stress and emotional reactions. Humans produce cortisol even when they are not stressed. However, through multiple pathways in the brain, both internal and external threats to well-being cause increased activity in the HPA system that raises cortisol levels over baseline (De Kloet, 1991). The HPA system is sensitive to both physical and psychological stressors, and is of special interest because of its close link to the hippocampus, which is involved in emotions, learning and memory (De Kloet, 1991). Thus, chronic exposure to stress in early childhood may be a risk for later affective and cognitive functioning.

Animal studies have shown that chronic activation of the HPA axis can compromise health, immune function, and subsequent stress responses. Most of these studies concerned maternal deprivation. Maternal separation has been shown to result in long-term physiological changes, including increases in cortisol (Gunnar, Gonzalez, Goodlin, & Levine, 1981; Liu, Caldji, Sharma, Plotsky, & Meaney, 2000). Recently, Sánchez et al. (2005) investigated the consequences of repeated maternal separations between 3 and 6 months of age on rhesus monkeys' HPA axis function, and found that repetitive maternal separation led to increased cortisol reactivity to the separation (in females only). Persistent changes in physiology were present after 6 months and over a year after separation: among other things, a flattened rhythm of cortisol was found.

Although the effects of early caregiving experiences on the neurobiological development have not been clearly demonstrated in humans and caution is needed in transposing results from animal models to humans, there is growing evidence converging with the findings from animal models. Recent theoretical reviews propose that adverse experiences early in life (e.g., maternal deprivation, emotional loss, orphanage rearing, maladaptive relationship with attachment figure, maltreatment) affect activity of the HPA system (Gunnar & Donzella, 2002), and that inadequate early caregiving is linked to physiological responses that can increase vulnerability to stress–related illness (Luecken & Lemery, 2004).

An important question that arises is to what extent caregivers 'buffer' HPA responding, in other words: does quality of caregiving influence the development of physiological stress responses? It has been shown that caregivers play important roles in regulating activity of the HPA system during development in non-human primate infants (Bayart, Hayashi, Raull, Barchas, & Levine, 1990) as well as human infants (Gunnar & Donzella, 2002). Among human infants, the security of the attachment relationship has been explored with regard to cortisol reactivity. In several studies it has been shown that children in insecure attachment relationships show more evidence of cortisol elevations than do securely attached children (e.g., Nachmias, Gunnar, Mangelsdorf, Hornik Parritz, & Buss, 1996; Spangler & Grossman, 1993). Furthermore, it has been shown that the availability of substitute caregivers who are sensitive and responsive may function as a buffer against stress responses. Gunnar, Larson, Hertsgaard, Harris, and Broderson (1992) demonstrated that stress responses to brief parental separations can be diminished in children by providing a sensitive, responsive alternative caregiver.

It is still unclear, however, what other elements in the children's early environment, besides the quality of caregiving provided by the parents or substitute caregivers, may influence their cortisol levels. Novelty has often been associated with increases in cortisol levels, but research findings are not consistent. De Haan, Gunnar, Tout, Hart, and Stansbury (1998), for instance, reported that childrens'cortisol levels did not increase when they first started pre-school as compared to either home or later school levels. Quas, Murowchick, Bensadoun, and Boyce (2002), however, found that children for whom kindergarten would be considerably different from their prior experiences showed increased cortisol levels after kindergarten entry. Dickerson and Kemeny (2004) performed a meta-analysis on laboratory studies of acute psychological stressors and conclude that tasks containing both uncontrollable and social-evaluative elements were associated with the largest cortisol changes in adults and the longest time to recover. According to the authors, these findings are consistent with the animal literature on the physiological effects of uncontrollable social threat, and contradict the belief that cortisol is responsive to all types of stressors. Laboratory studies on stress with adults cannot be generalized to naturalistic settings. However, there are reasons to believe that social threat in everyday situations may contribute to children's stress levels. Gunnar and colleagues have demonstrated, in a series of studies, that socially threatening contexts that are characterized by rejection increase cortisol levels in children (see Gunnar & Donzella, 2002). In daycare, with large peer groups, children are more vulnerable to socially threatening situations than in other environments. Gunnar, Sebanc, Tout, Donzella, and Van Dulmen (2003), for instance, reported that peer rejection in pre-school classrooms was associated with higher cortisol levels in 3–5-year olds.

Numerous questions remain about what child-related characteristics (e.g., temperament, age, gender) affect cortisol reactivity. Individual differences in children's stress reactivity have often been linked to temperamental characteristics. However, the literature reports mixed evidence for how these constructs are related. In some studies, high or increasing cortisol levels have been reported for extremely inhibited children (e.g., Gunnar et al., 2003), whereas other studies

have found positive relations between cortisol levels and outgoing or aggressive behavior (e.g., Dettling et al., 1999). Presumably, the outcomes may be confounded due to the different contexts in which relations are measured. Stress reactivity must be viewed as a dynamic construct, and may not only vary across individuals, but also across different situations (Gunnar, Tout, De Haan, Pierce, & Stansbury, 1997). For instance, in a study performed by De Haan et al. (1998) cortisol and shy/anxious behavior were positively correlated when cortisol was sampled at home, but not when cortisol was sampled in preschool for the same children.

In all studies on cortisol reactivity, an important factor that may influence the outcome is the time of day of testing. It has been found that cortisol production follows a circadian rhythm. However, it is still unclear how individual variations (e.g., age, gender, temperament) and different contexts (e.g., familiar and novel) may influence this rhythm. Cortisol levels have been found to be well established in adults, with the majority showing highest levels approximately 30 min after wake-up, followed by a sharp decrease over the next 2 h, and then a more gradual decline over the remaining daytime and evening hours (Kirschbaum & Hellhammer, 1989). There is evidence that the same diurnal pattern can be recognized in children. Gunnar and Donzella (2002) described the pattern in cortisol production for young children at home over the first three years of life combining information from three studies. Overall, a daily rhythm in cortisol with high levels early in the morning and lowest levels in the evening was apparent from the earliest age tested (2 months) to the eldest age (36 months). Watamura, Donzella, Kertes, and Gunnar (2004) used a cross-sectional design to compare salivary cortisol levels at home of 77 children aged 12, 18, 24, 30, and 36 months. Across all ages, a clear daytime rhythm in cortisol production was found: cortisol levels were highest at wake-up and lowest at bedtime. Because the circadian rhythm varies among individuals and among contexts, it is important to use home baseline measures as well in studies on cortisol production in daycare. This enables us to make intraindividual comparisons across these contexts, and thus to examine influences of daycare on cortisol levels.

The purpose of this paper is to review the literature on children's cortisol levels at center daycare. Important questions are whether (1) cortisol patterning is different for home compared to daycare, and (2) cortisol levels are associated with daycare features (e.g., quality of care), and child characteristics (e.g., age, gender, temperament).

1. Method

As a first step, we systematically searched the electronic databases ERIC, Current Contents, PsychInfo and PubMed using single and combined search terms as follows: cortisol, adrenocortical, neuroendocrine, daycare, childcare, center/centre care. Second, the references of the collected papers were searched for relevant studies. Studies were included in the review if they reported the measurement of children's cortisol levels in full-day childcare centers.

2. Results

We found nine papers in which children's cortisol levels in daycare settings were measured. For an overview of these studies, see Table 1. In seven studies, saliva samples were collected, whereas in the studies of Lundberg (1983) and Lundberg, Westermark and Rasch (1993) urine samples were used. Seven studies examined cortisol levels both at home and at daycare for the same sample, and seven (other, partly overlapping) studies addressed children's diurnal patterns (samples collected at various time points during the day) in cortisol levels at daycare only. The studies in which both home and daycare cortisol was assessed for the same children (intraindividual differences) were included in a meta-analysis. Table 1 outlines what information was provided by each study. Furthermore, we examined all papers on possible associations between cortisol levels and quality of care, and the influences of age, gender, and children's temperament.

2.1. Cortisol patterning at home versus daycare

In seven studies, children's cortisol levels were examined both at home and at childcare. In the study of Lundberg (1983), cortisol excretion of 26 children (3–6 years) was examined at daycare and at home. Because the times for urine sampling varied between children, a total mean value was calculated for each child. All urine samples were obtained between 8.00 a.m. and 4.00 p.m. on a day at the daycare center and on a Saturday or Sunday at home. It was found that cortisol excretion did not differ significantly between the two conditions.

Table 1
Studies included in the review and meta-analysis

Study	Continent of study	Sample size (*n*)		Age (months)		Measure	Matched time points (home vs. daycare)	Effect size (*r*)
		Total	Meta	*M*	Range			
Ahnert et al. (2004)[a,b]	Europe	67	67	20[c]	16–25	Saliva	Yes	.19
Dettling et al. (1999)[a,b]	USA	70	51	69[d]	39–106	Saliva	Yes	.14
Dettling et al. (2000)[b]	USA	21	n.a.	52[d]	35–63	Saliva	n.a.	n.a.
Legendre (2003)[a,b]	Europe	113	74	30	18–40	Saliva	Yes	.14
Lundberg (1983)[a]	Europe	26	26	54	33–76	Urine	No	.00
Lundberg et al. (1993)[a]	Europe	43[e]	43	66	60–71	Urine	No	.00
Tout et al. (1998)[b]	USA	75	n.a.	52	34–61	Saliva	n.a.	n.a.
Watamura et al. (2002)[a,b]	USA	35	8	49	34–65	Saliva	Yes	.39
Watamura et al. (2003)[a,b]	USA	55	34	20	2–38	Saliva	Yes	.55
Total		505	303	46	2–106			.18

n.a. = not applicable.
[a] Included in the meta-analysis.
[b] Describing diurnal patterns in daycare.
[c] Five months after daycare entry.
[d] Median.
[e] Follow-up after 2 years.

Ten years later, Lundberg et al. (1993) determined cortisol levels of 60 children from urine samples collected at the ages of 3.5 and 5.5. For both home and daycare measures, a mean value was calculated from all urine samples (usually 2) collected from about 9 a.m. to 2.30 p.m. Analyses revealed that no differences in cortisol excretion were apparent at the age of 3.5, whereas at the age of 5.5, cortisol excretion was significantly lower at the daycare center than at home.

Dettling et al. (1999) examined cortisol levels of 51 children, aged 39–106 months, both at home and at daycare. Saliva samples were collected mid-morning and mid-afternoon on 2 days at childcare and 2 days at home. These samples were averaged within context and time point. A decrease in cortisol levels from morning to afternoon was observed at home, but not at childcare. For the total sample, changes form morning to afternoon were −.06 (in μg/dl) for the home measurements, and +.02 for the childcare measurements. No significant associations were found between age and cortisol levels at home. However, relations were reported between age and cortisol levels at childcare. Only the youngest children ($n = 18$; 3 and 4 years old) had afternoon cortisol levels at childcare that were significantly higher than their levels at home. Approximately 80% of these children exhibited increases in cortisol from mid-morning to mid-afternoon. It was reported that mid-afternoon levels, but not mid-morning levels, differed between home and daycare.

Watamura, Sebanc, and Gunnar (2002) collected saliva samples of 35 children from four classrooms in daycare. Two classrooms served younger children ($M = 3.45$), and two served older preschoolers ($M = 4.67$ years). For a subset of these children ($n = 8$) home saliva samples were collected as well. Cortisol was measured during childcare at 10:30 a.m., pre-rest, post-rest, and 3:30 p.m. The measurements at home were at 10:30 a.m. and 3:30 p.m. For 90% of the children, cortisol rose at childcare: cortisol change from morning to afternoon was .15. Seventy-five percent of the subset of eight children showed a decrease in cortisol from morning to afternoon at home (cortisol change was −.07). Pairwise comparisons between home and childcare values at 10:30 and 3:30 yielded a significant difference only for the afternoon value: cortisol levels at childcare were significantly higher than the home values.

Watamura, Donzella, Alwin, and Gunnar (2003) included younger children in their study: both home and daycare data on cortisol levels were available for 36 children (14 infants and 22 toddlers). Results showed the same pattern that was found by Dettling et al. (1999): at home there was no significant change in cortisol over the day, whereas at childcare the time-of-day effect was significant. Home cortisol levels (both at mid-morning and mid-afternoon) were lower than daycare cortisol levels at the same time points. Furthermore, for the different age groups, no change in cortisol was found over the day at home. At childcare, 35% of the infants (3–16 months) showed a rise in cortisol across the day, whereas among the toddlers (16–38 months), 71% showed a rise.

Legendre (2003) reported on 113 children from 18 to 40 months ($M = 30$ months), who were regularly attending daycare centers in France (six groups) and Hungary (two groups). Three saliva samples were collected: parents were

asked to take a first sample at home when the child woke up, and two samples were taken at daycare, at 9:30 a.m. and 10.30 a.m., before and after a regular free play session. This was repeated on 3 days spread over a 2-week period. In one group ($n = 13$), saliva samples were also collected at home on Saturday at the same time of the day. For this group, it was found that between 9:30 a.m. and 10.30 a.m., there was no significant change in cortisol level at the daycare centers, whereas at home there was a significant decrease in cortisol level. It was not reported whether the 9:30 and 10:30 measures differed between home and daycare.

Ahnert, Gunnar, Lamb, and Barthel (2004) studied the cortisol responses of 67 toddlers (aged 15 months) in transition to child care. Saliva samples were collected at home almost 2 weeks before starting child care, and at childcare on the first and last day during the adaptation phase (with mothers present), at day 1, day 5, and day 9 during the separation phase (first 9 days without mother), and 5 months after child care entry. Security of infant-mother attachment was assessed before and 3 months after child care began. The study was conducted in Germany, where mothers are encouraged to remain with their children in the child care setting during a transitional period to help them adapt before the first child care separation. In this study, mothers spent between 0 and 30 days adapting their toddlers to child care. Saliva samples were taken three times, 30 min apart, on each assessment day. At home, this was scheduled around the time when the mothers intended to take their children to the center. At childcare, the first sample was taken after the child arrived at the center, and then after 30 and 60 min, respectively. The authors conclude that entry into child care was stressful for the toddler. It was found that higher cortisol levels were evident in the child care setting, even with the mother present, than at home. In the separation phase, cortisol rose over the first hour following the mothers' departures to levels that were 75–100% higher than at home. Even though the children appeared to adapt over the following months, cortisol levels were still significantly higher than home baseline levels 5 months after child care began. Furthermore, cortisol increases during the adaptation phase were lower in securely attached than in insecurely attached children.

Two additional studies provided data on cortisol patterns in daycare, without providing data for the home measurements. Tout, De Haan, Kipp Campbell, and Gunnar (1998) examined daily patterns in cortisol excretion in 75 children attending two childcare centers. The children ranged in age from 2 years 8 months to 5 years 10 months ($M = 4.3$). For a period of approximately 30 days, each center was visited twice daily (10:30 a.m. and 3:00 p.m.) to collect saliva samples. Samples from individual children were assayed only if at least 10 morning and afternoon samples (morning $M = 16$ samples; afternoon $M = 15$ samples) were provided. A measure of central tendency (median) of cortisol values was used that would be relatively unaffected by one or two instances of high cortisol. A significant time-of-day effect was found for this measure: cortisol levels increased significantly from morning to afternoon. Eighty-one percent of the children displayed this rise in cortisol at daycare.

The center-based childcare sample as described by Dettling, Parker, Lane, Sebanc, and Gunnar (2000) included 21 children with an age range of 35–63 months (median = 52 months). Saliva samples were collected at mid-morning (10:30–10:45) and at mid-afternoon (15:30–15:45) on 2 days. Mean morning value was .15 (salivary cortisol in μg/dl), whereas mean afternoon value was .22.

In conclusion, in four of the seven studies on intraindividual differences in cortisol excretion, significant differences between children's cortisol levels at home versus daycare were reported. In these studies, no changes, or a decrease in cortisol levels at home were found, whereas cortisol levels at daycare increased significantly during the day. Two of these four studies reported significant differences only for the afternoon values. In the other three studies, no significant changes in cortisol levels at the daycare centers were found, whereas at home either a decrease or no change was apparent. It should be noted, however, that in two of these studies cortisol levels were determined from urine samples, instead of saliva samples. It is possible that in the Lundberg studies the method of cortisol collection is responsible for not finding any significant differences in children's cortisol levels at home versus daycare. Urinary cortisol is secreted slowly as the bladder fills, resulting in a lag time of several hours from cortisol production to cortisol collection (Baum & Grunberg, 1997). So, studies using urinary measures are probably primarily picking up morning cortisol production, even when samples are collected in the afternoon.

As for diurnal patterns, most studies (five out of seven) reported significant increases in cortisol levels at daycare from morning to afternoon. In one study (Dettling et al., 2000), there was an increase, but no information was provided concerning the statistical significance of this increase. Furthermore, in one study (Legendre, 2003) data were only available for the morning hours. During this period children's cortisol levels decreased at home, whereas they ceased to decrease at daycare. Fig. 1 reflects mid-morning and mid-afternoon cortisol levels for the home and childcare measures separately, compiling data from four studies, in which mean cortisol levels were reported for these time points.

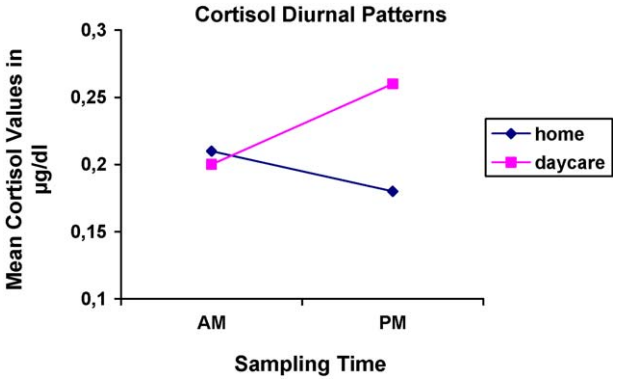

Fig. 1. Diurnal changes in cortisol levels between mid-morning (AM) and mid-afternoon (PM) at home and at daycare.
[These data were compiled from four studies using saliva samples (Dettling et al., 1999, 2000; Tout et al., 1998; Watamura et al., 2003)].

2.2. *Meta-analysis of home-daycare differences in cortisol*

In seven studies cortisol data at home and at center daycare were collected for $n = 303$ children. We computed effect sizes for each of the studies based on the last cortisol assessment at the center (see Table 1 for the effect sizes per study in terms of correlations). We found the seven outcomes to be a homogeneous data-set (Q(d.f. = 6) = 8.46, $p = .21$). The combined effect size for the seven studies was $r = .18$ ($p = .003$), with a 95% confidence interval of .06–.29. With the Duval and Tweedie trim and fill approach (Duvall & Tweedie, 2002a,b) we showed that our data-set did not suffer from publication bias. It would need another 19 unpublished studies with null effects for the association between cortisol and daycare to turn the current combined effect size into a statistically non-significant effect. Two studies showed a diverging design: the Lundberg studies were based on urinary cortisol estimates, and these studies did not match home and daycare cortisol collections for time of assessments. If these two outcomes were left out, the remaining salivary cortisol studies showed a combined effect size of $r = .23$ (CI = .10–.35; $p = .001$), and the resulting data-set was homogeneous (Q(d.f. = 4) = 5.88, $p = .21$). The effect of daycare attendance on cortisol excretion was especially notable in children younger than 36 months: $r = .25$ (CI = .10–.38; $p = .001$), whereas in children older than 36 months the combined effect size was not significant: $r = .08$ (CI = −.11–.25; $p = .41$). Because of the small data-set we did not conduct formal moderator tests.

In sum, meta-analytic evidence confirms the hypothesis that daycare children display a significantly different cortisol excretion pattern at daycare compared to the home setting. At daycare cortisol levels continue to be higher than at comparable times of assessment at home.

2.3. *Children's cortisol levels in relation to quality of care*

We found five studies in which relations between children's cortisol levels and quality of daycare were described. In four studies (Tout et al., 1998; Dettling et al., 1999, 2000; Watamura et al., 2003), children were recruited from high-quality centers. From these four studies, three studies (Dettling et al., 1999, 2000; Tout et al., 1998) recruited children from the same childcare center, namely a high quality childcare center serving children of university students, staff, and faculty parents. In 57% of the cases, children spent more than 30 h at this childcare center. In the two Dettling et al. studies, all children attended this university childcare center. In the Tout et al. study, two-third of the children came from this university center, whereas one-third were recruited from a community based childcare center. To assess quality, the Early Childhood Environment Rating Scale (ECERS; Harms & Clifford, 1980) was administered, as well as the Caregiver Interaction Scale (CIS; Arnett, 1989). The scores on both scales for the university-based center were consistently higher than the scores for the community-based center. The university-based center, which operates as a model childcare center used for training purposes, scored at ceiling on nearly all scales. Both centers, however, scored above the fiftieth percentile on the subscales of each measure (no means were reported), thus indicating that moderately high to extreme high quality was provided at both centers.

Participants in the study of Watamura et al. (2003) were recruited from four full-day childcare centers that served as research sites. These centers were also evaluated with the ECERS, and had a median score of 5.3 with a range of 4.2–6.8 (on a scale of 1–7, in which a 5 is indicated as good quality). One of the classrooms received an average score, whereas the other two classrooms scored in the good to excellent range of quality. Adult child ratios for infant rooms were 1:2–3 (4–9 infants), and for toddler rooms ratios were 1:4–6 (12–15 toddlers).

In these four studies, increases in children's cortisol levels were found during daycare visits, and in two of these studies, it was proved that cortisol levels were higher at childcare than at home. Thus, even in childcare centers of reasonable to high quality, children showed an increase in cortisol levels. Unfortunately, the childcare centers in these studies formed a homogeneous group, therefore not allowing an analysis of variations in daycare quality in relation to children's cortisol levels.

Legendre (2003) examined environmental features of the eight daycare centers in their study in relation to children's cortisol changes. Data were collected on group size, child-to-caregiver ratio, number of adults in the group, characteristics of the caregiver team, areas of indoor space and playrooms, and available space per child. It was found that cortisol increases were related to large group sizes ($n > 15$), important age differences among children (>6 months), less available area per child in the playrooms (<5 m^2), and large numbers of adults in the room (>4 adults).

2.4. Cortisol levels in daycare in relation to child characteristics

2.4.1. Age

From the nine studies in our review, seven distinguished between age groups. Lundberg et al. (1993) compared the cortisol excretion at the age of 3.5 and 5.5 in the same sample of children ($n = 46$) and found a significant increase with age. An interaction effect between condition and age revealed that the difference in cortisol excretion between home and daycare was more pronounced at the age of 5.5, with higher cortisol levels at home than at daycare.

Tout et al. (1998) reported significant negative correlations between age (range between 32 and 70 months) and both morning and afternoon cortisol levels at childcare. Age was negatively related to absolute cortisol values, but not to cortisol changes during the day.

Dettling et al. (1999) found no significant associations between age and cortisol levels at home. At childcare however, age was negatively related with cortisol levels in the afternoon. The percentages of the 3-, 4-, and 5-year old children in the preschool childcare center showing a rise in cortisol from morning to afternoon were 82, 63, and 50, respectively. These percentages of the 6-, 7-, and 8-year old children in school-age childcare center were 50, 31, and 27, respectively. An additional analysis using three age groups, namely 3- and 4-year olds ($n = 18$), 5- and 6-year olds ($n = 12$), and 7- and 8-year olds ($n = 21$), showed that the probability of a rise in cortisol over the day was the most marked among the youngest children. These 3- and 4-year olds had afternoon cortisol levels at childcare that were significantly higher than their levels at home.

Watamura et al. (2002) reported a negative correlation between age (range between 2.8 and 5.4 year) and the rise in cortisol over the child care day, implying that the younger children (around 3 years) showed higher increases in cortisol during the day than the older children (around 5 years). For cortisol measures obtained at home, there were too few children ($n = 8$) to examine age effects.

In the study of Watamura et al. (2003), no change in cortisol was found over the day at home for the different age groups. At childcare, 35% of the infants (3–16 months) showed a rise in cortisol across the day, whereas among the toddlers (16–38 months), 71% showed a rise. Although children 16 months and older were in the toddler classrooms, peak cortisol increases were not observed until 24–36 months. A curvilinear association was found between age and cortisol levels, with a peak around the 2–3-year olds.

Finally, two studies did not find relations between age and cortisol. Legendre (2003) found no significant relation between the cortisol change and the mean age of each group for the age range considered in this study (18–40 months). In the study of Ahnert et al. (2004) no significant effects were found, when comparing the younger (9–14 months at onset) and older (14–18 months at onset) toddlers in cortisol responses at the beginning and end of the study (first day of the adaptation phase versus 5 months later).

From the seven studies in which relations between age and cortisol levels were analyzed, four studies revealed significant associations for daycare only. In three studies (Dettling et al., 1999; Tout et al., 1998; Watamura et al., 2002) negative relations between age and cortisol levels at childcare were reported. The youngest children in these studies, who were about 3 years old, showed higher afternoon cortisol levels than the older children (5–8-year olds). In another

study (Watamura et al., 2003), finally, the rise in cortisol at childcare was more pronounced among the 16–38 months old children, compared to the infants (3–16 months). In one study (Lundberg et al., 1993), cortisol values rose with age, but only for the home measurements. Because of the limited number of children in each study, and the wide range in ages, it is difficult to draw conclusions based on these within-study comparisons only. A cautious conclusion is that higher rises in cortisol levels at daycare were found among the 3-year-old children, compared to the older children. Because the children from younger age groups were underrepresented in these studies, no inferences can be made for children under 3 years of age. Unfortunately, the studies do not provide detailed data on cortisol values for the different age groups, therefore not allowing us to perform across-study comparisons. Gunnar and Donzella (2002) compiled data from four studies, including the Tout et al. (1998), Dettling et al. (1999), and Watamura et al. (2003) studies. They noted that children between 21 and 40 months showed marked increases over the day in their cortisol levels, whereas this increase was not seen among the infants. The latter is in line with the results reported by De Weerth, Zijl, and Buitelaar (2003), who found important variability in the appearance, age, and stability of the circadian rhythm in young infants (2–5 months old).

Furthermore, the increase was less marked for children among 41–60 months of age, whereas the older children (71–100 months) showed decreasing cortisol levels during the day. Combining these results, a curvilinear relationship between age and cortisol levels with a peak around the 2–3-year olds, seems the most plausible conclusion thus far. This is in line with the results from the meta-analysis reported in this paper: the effect of day care attendance on cortisol excretion was especially notable in children younger than 36 months.

2.4.2. Gender

In seven studies, relations between gender and cortisol levels were examined, both at home and at daycare (Dettling et al., 1999; Legendre, 2003; Lundberg, 1983; Lundberg et al., 1993; Tout et al., 1998; Watamura et al., 2002, 2003). In none of these studies significant gender differences were found.

2.4.3. Temperament

In five studies, the child's temperament was examined in relation to cortisol levels at daycare. In two of these studies (Ahnert et al., 2004; Watamura et al., 2002) no significant relations between temperament and cortisol levels were found. Tout et al. (1998) used teacher ratings, providing information about children's positive behaviors and behavioral problems. Relations between cortisol and behavior differed by gender: significant associations were found for boys only. The rise in cortisol over the day was positively related with internalizing behavior in boys. Dettling et al. (1999) used the Child Behavior Questionnaire (CBQ; Ahadi, Rothbart, & Ye, 1993) describing three dimensions of temperament: negative affectivity, surgency or extroversion, and effortful control. Both parents and teachers assessed the child's temperament. Shyness in boys, and impulsivity, poor self-control, and aggression in both sexes were associated with greater increases in cortisol over the day. Furthermore, Watamura et al. (2003) found that teacher-reported social-fearfulness, as measured with the Infant Behavior Questionnaire (IBQ: Rothbart, 1981) and the Toddler Behavior Assessment Questionnaire (TBAQ; Goldsmith, 1996), predicted higher afternoon cortisol and larger cortisol increases across the day at child care.

Thus, the few studies that examined relations between temperament and children's cortisol levels during daycare, do not demonstrate linear relations between these two constructs. In two studies, relations between inhibited behavior (internalizing, shy) and cortisol were apparent for boys only. Furthermore, poor self-control, social fearfulness and aggression were related with higher cortisol levels. Different ways of measuring children's temperament may be responsible for these outcomes, as well as the exclusion of possible moderator variables, such as quality-of-care characteristics.

3. Discussion

We reviewed nine studies in which children's cortisol levels at center daycare were assessed. Our first hypothesis, concerning intraindividual differences in cortisol levels across home and daycare settings, was also tested in a meta-analysis. Our main finding is that at daycare children display higher cortisol levels compared to the home setting. In five of the seven reviewed studies, in which cortisol was measured at daycare at multiple time points during the day, significant increases were reported from morning to afternoon. This is in contrast with the daily rhythm in cortisol reported for the home settings, with high levels early in the morning and either a decrease or no increases in cortisol

from morning to afternoon. It should be noted that for some studies comparisons between home and childcare values at mid-morning and mid-afternoon yielded a significant difference only for the afternoon value. In these studies, effects were only notable after the children had been at daycare for several hours.

The second question concerned associations between cortisol levels and both daycare and child characteristics. Even in childcare centers of reasonable to high quality – as measured with a standard observation instrument for process quality – an increase in cortisol levels was found. Unfortunately, daycare centers of lower quality were not included in the set of studies. As a consequence, inferences about variations in daycare quality in relation to children's cortisol levels could not be made. As for the child characteristics, age appeared to be the most significant moderator of this relation, and was also included in the meta-analysis. The meta-analysis showed that the effect of daycare attendance on cortisol excretion was especially notable in children younger than 36 months. The small data-set, however, did not allow us to further distinguish between age groups under the age of 36 months. Therefore, the hypothesized curvilinear relation between age and cortisol levels, with a peak around 2–3 years, was not tested meta-analytically. Furthermore, the few studies that examined relations between temperament and cortisol levels at daycare, were not uniform in their conclusions. In two studies, a positive relation was found between inhibited behavior and higher cortisol levels, but this was found for boys only. For both sexes, poor self-control, social fearfulness and aggression were positively related with higher cortisol levels. This suggests that more than one temperament dimension is associated with increased activity of the HPA axis when children are in peer group settings. On the one hand, children who are exuberant and aggressive may experience social threat because their actions lead to negative peer and teacher responses. On the other hand, children who are shy and fearful may experience social threat when they must engage in interaction with other children.

From this review and meta-analysis we derive two important questions: (1) to what extent do these increases in cortisol levels affect children's development? and (2) what causes these increases in cortisol levels at daycare? As for the first question, none of the included studies were designed to examine the impact of the (small) increases of cortisol levels on child development. Therefore, it is not known whether the reported elevated cortisol levels at daycare are an adaptive context-specific response to the stresses of group life, or enduring and thus a risk for later development. In general, chronic increases in stress hormones are considered harmful because it may undermine the immune system (Sapolsky, 2004). Elevated cortisol levels may be a functional response to the strains and stresses of group life at daycare but at the same time make the child more vulnerable to illnesses. As for the risk for later development, prolonged elevated cortisol levels have been shown to cause cognitive impairments and illnesses in animals and in human adults (Luecken & Lemery, 2004). However, there is no empirical evidence that the elevated cortisol levels at daycare would have adverse implications for the children's later development. Some children with a reactive temperament who at an early age are confronted with fulltime stressful daycare without buffering social support may be most at risk, and further research is needed to substantiate this hypothesis of differential susceptibility (Belsky, 1997; Boyce & Ellis, 2005).

What makes it even more difficult to draw conclusions regarding elevations in cortisol, are the findings that cortisol excretion may also fluctuate as a function of physiological changes in the organism. For instance, napping (e.g., Watamura et al., 2004), respiratory illness, and feeding (De Weerth et al., 2003) have been found to influence the HPA axis. At daycare, the influence of these variables on cortisol excretion may be evident for all children simultaneously, and thus affect mean cortisol values of a whole group. Controlling for all these variables at different time points during the day is difficult. What is more, several studies have yielded evidence that cortisol levels can be lowered below baseline levels, even in situations that are highly novel for children (Gunnar & Donzella, 2002). Hence, more research is needed, in which special attention should be paid to the concurrent and predictive validity of cortisol measures in center daycare.

As long as results from longitudinal studies are not available, we can only speculate on the possible risks of the observed increases in cortisol levels at daycare. The literature has reported at least two findings that do not support the hypothesis that these patterns endure over the course of development. First, elevated cortisol levels have not been observed consistently across settings, and seem to be related to the specific context of daycare. After all, children's cortisol levels at home have been found to be lower than at daycare. An interesting question thus is whether interindividual differences exist in home cortisol levels between children who visit daycare centers and children who do not attend any type of childcare. If the stress that children experience in daycare does not have a carry-over effect to the home situation, their baseline cortisol levels at home should be comparable with those of children who are exclusively being raised at home. We found one study that supports this hypothesis. Watamura et al. (2004) distinguished between children (aged 12–36 months) who were raised exclusively by their parents (or received less than 10 h a week of

nonparental care), and children who received at least 10 h a week of nonparental care. When comparing the cortisol levels at home, no significant differences were found between the two groups. Apparently, (some) children display an adaptive cortisol response to the challenges at daycare, and are, at the same time, capable of a physiological recovery when at home. Second, the observed higher cortisol levels at daycare seem to disappear when children grow older. This has not only been demonstrated in cross-sectional studies, but also in a longitudinal study. Lundberg (1983) measured cortisol levels of the same sample of children at different ages, and found that at the age of 5.5 children's cortisol excretion was significantly lower at the daycare center than at home, whereas no differences were apparent at the age of 3.5. However, these findings do not allow us to conclude that there are no long-term consequences for HPA axis regulation. Daycare may not longer be a challenge that elicits a cortisol response, but these children may still respond stronger to other stressors.

As for the second question, several mechanisms that stimulate a rise in cortisol at daycare centers can be suggested. It is unlikely that the mere separation of the parents causes elevated cortisol levels. If this were the case, higher cortisol levels would be found in children who just started visiting daycare. Ahnert et al. (2004) demonstrated that entry into child care was stressful for toddlers, but this was found even when their mothers were present. Cortisol levels were elevated over home baseline levels in both securely and insecurely attached toddlers. These authors suggest that the novelty of the setting and the numerous new social partners may have stimulated increased activity of the HPA axis. Moreover, Dettling et al. (2000) found that children who were reared in home-based childcare, which in terms of adult-child ratio was comparable with center-based childcare, did not show elevations in cortisol levels. In our view, the most plausible explanation lies in a complex interaction between the quantity of daycare attendance (both length of the day and hours a week), the quality of the daycare setting, and characteristics of the child itself. The amount of time that children spend in large groups with peers might contribute to elevated cortisol levels. Studies (Gunnar et al., 1997) in which the cortisol excretion was measured of children who attended half-day childcare did not point to an elevated cortisol level, neither in the morning nor in the afternoon. In four of the seven studies in our meta-analysis it was reported that children spent at least 30 h a week at daycare. Thus, cortisol elevations are not apparent, or less evident, in children who attend part-time daycare.

Animal studies have shown that the amount of peer interaction is related to cortisol levels. Shannon, Champoux, and Suomi (1998) reported that infant rhesus monkeys, who were housed continuously as groups of four, had significantly higher cortisol levels than monkeys, who received 2 h of peer experience per day. In a recent study with rhesus monkeys, Capitanio, Mendoza, Mason, and Maninger (2005) found that the more time infants spend with peers on a daily basis, the higher the cortisol concentrations. It is still unclear, however, what the precise nature is of these peer interactions, and whether these results also apply to human infants in center daycare. More time in a peer group may result in increased opportunities for conflict, especially for young children. Dickerson and Kemeny (2004) found in their meta-analysis that uncontrollable social-evaluative threat elicited the largest cortisol increases in adults. It is very well possible that a large peer group may provoke, at least for some children, a large amount of social-evaluative threat. Very young children, who have not yet developed sufficient linguistic, social, and self-regulatory skills to handle various situations, may often be involved in situations in which a desired outcome is beyond their reach. For instance, they do not have the capacities to argue and negotiate over toys and play activities. Furthermore, elements of competition may be involved, which can be an important source of stress as well (Donzella, Gunnar, Krueger, & Alwin, 2000). Of course, both the child's temperament and the caregivers' skills may play a crucial role. If caregivers do not succeed in providing a secure base, supply sufficient opportunities for quiet play, and do not adequately steer and stimulate peer interactions, it can be expected that children will experience desired outcomes beyond their control.

As for temperament, social-evaluative threat may be experienced to a larger extent by children with high social fearfulness and low effortful control. Effortful control has been hypothesized to be the dimension of temperament that influences how well children can regulate behavioral and physiological responsivity under conditions of high emotional challenge (Eisenberg et al., 2004). Some studies reported that children who tend to be less socially competent and are more disliked by peers are more likely to show rising patterns of cortisol as the childcare day progresses (Gunnar et al., 1997). Future studies should include children's temperament in a systematic way, using instruments that measure both reactive and regulatory components of temperament.

The quality of child care, finally, seems to matter. Although the studies in our review formed a rather homogeneous group in terms of child care quality, some associations between child care quality and children's cortisol levels were found. Legendre (2003) found, among other things, that groups made up of more than 15 children showed cortisol increases. Unfortunately, group size could not be included in our meta-analysis, because data were not available from

three of the seven studies. Tout et al. (1998) reported that in the center scoring higher on quality, 73% of the children showed a rise in cortisol, whereas in the center scoring lower on quality, 96% showed the rise. Thus, even within the range of childcare that would be considered good to excellent, elevations in cortisol levels have been noted. Because many children experience childcare of average and even poor quality, more cortisol research is needed in a wider range of childcare quality. Dettling et al. (2000) found that lower quality care leads to higher cortisol values. In lower quality settings, defined by the quality of focused attention/stimulation, children tended to exhibit a rising pattern of cortisol over the day, whereas in higher quality settings this was not the case.

In order to disentangle the various elements that might contribute to children's elevated cortisol levels at daycare, we need studies that systematically control for possible moderator effects, such as quantity and quality of care, age and temperament. To understand which component of quality of care is important in regulating children's cortisol responses to the challenges of daycare, future studies should incorporate multiple measures of child care quality, both at the structural and process level. Simultaneous assessments of both cortisol excretion and children's actual behaviors and responses that are elicited by the specific context of center daycare, may provide more insights into the amount of stress that children are exposed to, as well as into the type of stressors and children's coping styles. Finally, longitudinal studies are needed to study the impact of cortisol excretion at daycare on children's well-being and development. We know that at daycare children display higher cortisol levels compared to the home setting but we do not know yet what component of daycare triggers this response and how frequently elevated cortisol excretion affects stress regulation at a later stage of development.

References

Ahadi, S. A., Rothbart, M. K., & Ye, R. (1993). Children's temperament in the U.S. and China: Similarities and differences. *European Journal of Personality*, *7*, 359–377.

Ahnert, L., Gunnar, M. G., Lamb, M. E., & Barthel, M. (2004). Transition to child care: Associations with infant-mother attachment, infant negative emotion, and cortisol elevations. *Child Development*, *75*, 639–650 (this study was included in the meta-analysis).

Arnett, J. (1989). Caregivers in day-care centers: Does training matter? *Journal of Applied Developmental Psychology*, *10*, 541–552.

Baum, A., & Grunberg, N. (1997). Measurement of stress hormones. In S. Cohen, R. C. Kessler, & L. U. Gordon (Eds.), *Measuring stress: A guide for health and social scientists*. New York: Oxford University Press (pp. 175–192).

Bayart, F., Hayashi, K. T., Raull, K. F., Barchas, J. D., & Levine, S. (1990). Influence of maternal proximity on behavioral and physiological responses to separation in infant rhesus monkeys. *Behavioral Neuroscience*, *104*, 98–107.

Belsky, J. (1997). Theory testing, effect-size evaluation, and differential susceptibility to rearing influences: The case of mothering and attachment. *Child Development*, *68*, 598–600.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context. I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*, 271–301.

Capitanio, J. P., Mendoza, S. P., Mason, W. A., & Maninger, N. (2005). Rearing-environment and hypothalamic-pituitary-adrenocortical regulation in young rhesus monkeys (*Macaca mulatta*). *Developmental Psychobiology*, *46*, 318–330.

De Haan, M., Gunnar, M. R., Tout, K., Hart, J., & Stansbury, K. (1998). Familiar and novel contexts yield different associations between cortisol and behavior among 2-year-old children. *Developmental Psychobiology*, *31*, 93–101.

De Kloet, E. R. (1991). Brain corticosteroid receptor balance and homeostatic control. *Frontiers in Neuroendocrinology*, *12*, 95–164.

De Weerth, C., Zijl, R. H., & Buitelaar, J. K. (2003). Development of cortisol circadian rhythm in infancy. *Early Human Development*, *73*, 39–52.

Dettling, A. C., Gunnar, M. R., & Donzella, B. (1999). Cortisol levels of young children in full-day childcare centers: Relations with age and temperament. *Psychoneuroendocrinology*, *24*, 519–536 (this study was included in the meta-analysis).

Dettling, A. C., Parker, S. W., Lane, S., Sebanc, A., & Gunnar, M. R. (2000). Quality of care and temperament determine changes in cortisol concentrations over the day for young children in childcare. *Psychoneuroendocrinology*, *25*, 819–836.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *3*, 355–391.

Donzella, B., Gunnar, M. R., Krueger, W. K., & Alwin, J. (2000). Cortisol and vagal tone response to competitive challenge in preschoolers: Associations with temperament. *Developmental Psychobiology*, *37*, 209–220.

Duvall, S., & Tweedie, R. (2002a). A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *Journal of the American Statistical Association*, *95*, 89–98.

Duvall, S., & Tweedie, R. (2002b). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*, 455–463.

Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reisers, M., Cumberland, A., Shepard, S. A., et al. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Development*, *75*, 25–46.

Goldsmith, H. H. (1996). Studying temperament via construction of the Toddler Behavior Assessment Questionnaire. *Child Development*, *67*, 218–235.

Gunnar, M. R., & Donzella, B. (2002). Social regulation of the cortisol levels in early human development. *Psychoneuroendocrinology*, *27*, 199–220.

Gunnar, M. R., Gonzalez, C. A., Goodlin, B. L., & Levine, S. (1981). Behavioral and pituitary–adrenal responses during a prolonged separation period in infant rhesus macaques. *Psychoneuroendocrinology*, *6*, 65–75.

Gunnar, M. R., Larson, M. C., Hertsgaard, L., Harris, M. L., & Brodersen, L. (1992). The stressfulness of separation among nine-month-old infants: Effects of social context variables and infant temperament. *Child Development*, *63*, 290–303.

Gunnar, M. R., Sebanc, A. M., Tout, K., Donzella, B., & Van Dulmen, M. M. H. (2003). Peer rejection, temperament, and cortisol activity in preschoolers. *Developmental Psychobiology*, *43*, 346–358.

Gunnar, M. R., Tout, K., De Haan, M., Pierce, S., & Stansbury, K. (1997). Temperament, social competence, and adrenocortical activity in preschoolers. *Developmental Psychobiology*, *31*, 65–85.

Harms, T., & Clifford, R. M. (1980). *Early Childhood Environment Rating Scale*. New York: Teachers College Press.

Kirschbaum, C., & Hellhammer, D. H. (1989). Salivary cortisol in psychobiological research: An overview. *Neuropsychobiology*, *22*, 150–169.

Kirschbaum, C., & Hellhammer, D. H. (1994). Salivary cortisol in psychoneuroendocrine research: Recent developments and applications. *Psychoneuroendocrinology*, *19*, 313–333.

Lamb, S., & Zakhireh, B. (1997). Toddlers' attention to the distress of peers in a day care setting. *Early Education and Development*, *8*, 105–118.

Legendre, A. (2003). Environmental features influencing toddlers' bioemotional reactions in day care centers. *Environment and Behavior*, *35*, 523–549 (this study was included in the meta-analysis).

Liu, D., Caldji, C., Sharma, S., Plotsky, P. M., & Meaney, M. J. (2000). Influence of neonatal rearing conditions on stress-induced adrenocoricotropin responses and norepinepherine release in the hypothalamic paraventricular nucleus. *Journal of Neuroendocrinology*, *12*, 5–12.

Luecken, L. J., & Lemery, K. S. (2004). Early caregiving and physiological stress responses. *Clinical Psychology Review*, *24*, 171–191.

Lundberg, U. (1983). Sex differences in behaviour pattern and catecholamine and cortisol excretion in 3–6 year old day-care children. *Biological Psychology*, *16*, 109–117 (this study was included in the meta-analysis).

Lundberg, U., Westermark, O., & Rasch, B. (1993). Cardiovascular and neuroendocrine activity in preschool children: Comparison between day-care and home levels. *Scandinavian Journal of Psychology*, *34*, 371–378 (this study was included in the meta-analysis).

Nachmias, M., Gunnar, M., Mangelsdorf, S., Hornik Parritz, R., & Buss, K. (1996). Behavioral inhibition and stress reactivity: The moderating role of attachment security. *Child Development*, *67*, 508–522.

Quas, J. A., Murowchick, E., Bensadoun, J., & Boyce, W. T. (2002). Predictors of children's cortisol activation during the transition to kindergarten. *Development and Behavioral Pediatrics*, *23*, 304–313.

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*, 569–578.

Sánchez, M. M., Noble, P. M., Lyon, C. K., Plotsky, P. M., Davis, M., Nemeroff, C. B., et al. (2005). Alterations in diurnal cortisol rhythm and acoustic startle response in nonhuman primates with adverse rearing. *Biological Psychiatry*, *57*, 373–381.

Sapolsky, R. M. (2004). *Why zebras don't get ulcers* (3rd ed.). New York: Henry Holt.

Shannon, C., Champoux, M., & Suomi, S. J. (1998). Rearing condition and plasma cortisol in rhesus monkey infants. *American Journal of Primatology*, *46*, 311–321.

Spangler, G., & Grossman, K. E. (1993). Biobehavioral organization in securely and insecurely attached infants. *Child Development*, *64*, 1439–1450.

Tout, K., De Haan, M., Kipp Campbell, E., & Gunnar, M. R. (1998). Social behavior correlates of cortisol activity in child care: Gender differences and time-of-day effects. *Child Development*, *69*, 1247–1262.

Watamura, S. E., Donzella, B., Alwin, J., & Gunnar, M. G. (2003). Morning-to-afternoon increases in cortisol concentrations for infants and toddlers at child care: Age differences and behavioral correlates. *Child Development*, *74*, 1006–1020 (this study was included in the meta-analysis).

Watamura, S. E., Donzella, B., Kertes, D. A., & Gunnar, M. R. (2004). Developmental changes in baseline cortisol activity in early childhood: Relations with napping and effortful control. *Developmental Psychobiology*, *45*, 125–133.

Watamura, S. E., Sebanc, A. M., & Gunnar, M. R. (2002). Rising cortisol at childcare: Relations with nap, rest, and temperament. *Developmental Psychobiology*, *40*, 33–42 (this study was included in the meta-analysis).