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The Impact of Program Structure on Cortisol Patterning in Children Attending Out-of-Home Child Care

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Abstract

Full-day center-based child care has repeatedly been associated with rising levels of cortisol, a hormone that helps the body manage challenge, across the day at child care. This article presents findings from two studies examining the relationship between child care program structure (number of days per week, and hours per day) and cortisol production across the day. Study 1 presents findings comparing cortisol production in 3- to 5-year-old children enrolled in either full-day ($N = 55$) or half-day ($N = 63$) Head-Start-funded programs. Study 2 presents findings comparing young children enrolled in either full-day full-time (5 days per week; $N = 37$) or full-day part-time (2–3 days/week; $N = 41$) primarily tuition-funded programs. Using multilevel modeling and controlling for a number of child factors, attending full-day, full-time programs (as compared to either half-day or part-time programs) was associated with increased cortisol production across the day on child care and home days. Implications for early childhood educators are discussed.

Keywords

child care; cortisol; stress; program structure

The increased use of non-parental child care has resulted in substantial research investigating the potential effects and associations of this important developmental setting on many aspects of child development, including school readiness and socio-emotional well-being. One way of assessing the impact of child care settings is by examining associations between child care characteristics and children's physiology, specifically examining production of cortisol, a hormone sensitive to stress and challenge. There has been a robust and replicated finding that preschool-aged children attending group child care settings may show a flat or rising pattern of cortisol production across the day at child care but a declining

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pattern at home (Geoffroy, Côté, Parent, & Séguin, 2006; Groeneveld, Vermeer, van IJzendoorn, & Linting, 2010; Vermeer & van IJzendoorn, 2006; Watamura, Coe, Laudenslager, & Robertson, 2010; Watamura, Kryzer, & Robertson, 2009). This flat or increasing pattern of cortisol across the day (typically resulting from elevated afternoon cortisol values) is limited to child care days, and by bedtime, cortisol levels on child care days are indistinguishable from bedtime cortisol levels on non-child care days (Sumner, Bernard, & Dozier, 2010; Watamura et al., 2009). While it remains unclear whether there are any consequences, positive or negative, of such patterning differences between home and child care, the evidence does suggest that a rising pattern across the day at child care is more pronounced in environments rated as lower in quality (Sims, Guilfoyle, & Parry, 2006; Hatfield, Hestenes, Kintner-Duffy, & O'Brien, 2013), is more common in children with more insensitive or intrusive teachers or who have less secure attachments to teachers (Badanes, Dmitrieva & Watamura, 2012; Gunnar, Kryzer, Van Ryzin, & Phillips, 2010), and is associated with lower antibody production on subsequent weekend days (Watamura et al., 2010). The studies presented in this paper will address the role of preschool program structure (full-day/full-time, full-day/part-time, and half-day) as associated with group differences in children's diurnal cortisol patterning.

Over the past several decades, there has been a substantial shift in the normative developmental experiences for infants and young children in the US. Specifically, both social and cultural changes, such as the increased rates of maternal employment, have made non-parental child care a necessity for some families (Hernandez, 1995), and many families choose preschool programs to help prepare their children for school entry. The National Institute of Child Health and Development (NICHD) Early Child Care Research Network (ECCRN) reported that the average age of entry for ECE settings was just before six months of age and that the average enrollment arrangement was over 20 hours per week (1997). Many children participate in some form of non-maternal child care (NICHD ECCRN, 2006) often beginning in infancy, and many children participating in non-maternal child care are served by out-of-home child care centers, with over 50% of children between the ages of three and six enrolled in either a kindergarten or a pre-kindergarten program (U.S. Census Bureau, 2009). The widespread utilization of non-maternal care has resulted in early care and education (ECE) settings becoming the second most important context for many children, outside of the immediate family context, as school settings are for older children. Children will often experience a variety of child care options (e.g., kin care, family based child care, and center based preschool programs) before they enter school (Laughlin, 2013).

Child care influences depend heavily upon several factors including caregiver sensitivity, adult-to-child ratio, and stimulation provided in the environment. Empirical research has consistently highlighted an array of benefits which can be gained from group care and education prior to school, particularly when children come from disadvantaged home environments (Lamb, 1997, 2000; Phillips & Lowenstein, 2011). The NICHD ECCRN found that high-quality child care was associated with a wide range of benefits including higher levels of cognitive and language development (2000, 2002, 2004) and more positive social and peer outcomes at 36 months (1998, 2001). However, not all outcomes associated with child care attendance are positive as some negative associations with time spent in child care have also been demonstrated. Notably, more hours spent in child care has been

linked to increased externalizing behaviors and more negative peer interactions in children (NICHD ECCRN, 1998, 2002, 2003, 2006; Phillips & Lowenstein, 2011; Vandell, 2004). If children benefit cognitively from high-quality early child care experiences, but are at an increased risk for externalizing problems if they spend long hours in these environments, a more comprehensive comparison of the costs and benefits associated with full and part-time programs is warranted.

The preschool years are an important developmental period during which many physiological processes are developing and experiences during this time period may help establish long-term physiological parameters, such as set points for stress reactivity (Gunnar & Cheatham, 2003). One widely studied physiological system is the hypothalamic-pituitary-adrenal (HPA) axis. The HPA-axis is a physiological system that serves regulatory functions for many different biological processes (e.g., metabolism, immune function) and helps manage the stress response. In humans, the primary downstream product of the HPA-axis is the glucocorticoid hormone cortisol. The HPA-axis may increase cortisol production in response to external threats to increase the amount of energy available for immediate use so that an organism may navigate the situation efficiently before returning to baseline. This system is most effective when used in a targeted fashion to help the body increase its energy levels in situations where immediate action may be warranted, while chronic activation of this system can incur a high metabolic cost (Dallman, 1993).

In adults in the absence of acute stress, cortisol production typically follows a circadian rhythm which peaks in the morning, sharply declines following the awakening peak, and then gradually decreases across the remainder of the day until reaching its lowest point around midnight (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). Circadian cortisol patterning is not present at birth and, depending on individual characteristics, a morning peak and evening nadir can start to emerge at various times across the first year of life (de Weerth, Zijl, & Buitelaar, 2003). Throughout the infant and toddler years, cortisol patterning further matures so that by age three, children show a decreasing pattern across the day, including across the afternoon under at-home, basal conditions (Larson, White, Cochran, Donzella, & Gunnar, 1998; Price, Close, & Fielding, 1983; Watamura, Donzella, Kertes, & Gunnar, 2004). Atypical cortisol patterning (flat or rising across the day instead of falling) has also been documented in both youth (White, Gunnar, Larson, Donzella, & Barr, 2000) and adults (Giese-Davis, Sephton, Abercrombie, Durán, & Spiegel, 2004; Sephton, Sapolsky, Kraemer, & Spiegel, 2000; Stone et al., 2001; White et al., 2000) and in these age groups, this atypical cortisol patterning is usually associated with difficult life experiences (Miller, Chen, & Zhou, 2007) or physical or mental health conditions (Herbert, 2013). A particularly problematic pattern is flat and very low cortisol across the entire day and/or a failure to respond to stress (Gunnar & Vasquez, 2001) which has been documented in high-risk preschoolers (Badanes, Watamura, & Hankin, 2011; Hankin, Badanes, Abuela, & Watamura, 2010). This has been referred to as hypocortisolism, hypocortisolemia, or attenuated cortisol.

Research has begun to elucidate possible risk and buffering effects which contribute to many young children showing flat or increasing cortisol across the day at child care (generally resulting from elevated afternoon levels) while showing the age-typical decreasing pattern at

home. Possible buffering factors for children displaying these patterns at child care include child care characteristics such as increased levels of attention and stimulation by the caregiver (Dettling, Parker, Lane, Sebanc, & Gunnar, 2000), higher industry standards for classroom quality (Sims, et al., 2006), more positive and cohesive classroom environments (Watanura et al., 2009), and classroom emotional support (Hatfield, et al., 2013). Child characteristics, including age (Dettling, Gunnar, & Donzella, 1999), secure attachments to mothers (Ahnert, Gunnar, Lamb, & Barthel, 2004) and caregivers (Badanes, et al., 2012) have also been shown to buffer this effect. A number of risk factors for elevated cortisol patterning at child care have also been identified including intrusive or over-controlling caregiving styles (Gunnar, et al., 2010), classroom interactional demands (Watanura et al., 2010), and a mis-match in quality between the home environment and the child care environment (Berry et al., 2013). Child characteristics including internalizing symptoms in boys (Tout, de Haan, Campbell, & Gunnar, 1998) and younger age (Dettling et al., 2000) have also been associated with increased cortisol production at child care. Note that in this literature, child care attendance has not been associated with the particularly problematic flat and low cortisol profile discussed above.

While family needs and funding constraints are critical determinants of child care options, understanding the cognitive, social-emotional, physical, and physiologic impacts of various program structures will help caregivers and parents make informed decisions about offering and choosing program types for individual children (when choice is possible). In the current studies, we examined whether salivary cortisol patterning differed across the day in programs with different structures. In order to assess the effects of program structure without confounding family characteristics or program goals (and within the constraints of program options offered in our community), we conducted two studies, one comparing full-day/full-time to half-day (morning only) Head Start programs and one comparing full-day/full-time (5 days/week) to full-day/part-time (2–3days/week) tuition-supported child care programs. Methods across the studies were kept very similar to allow for a more integrated discussion.

To our knowledge, there has not been any published research examining program structure (i.e., half-day or part-time vs. full-day/full-time attendance) on children's cortisol patterning, although the long hours spent in full-time child care may be a contributing factor to the flat or rising cortisol patterning some preschoolers show on child care days. Specifically, we hypothesize that enrollment in full-time, full-day child care programs may increase the likelihood of children showing flat or rising patterns of cortisol across the day as these cortisol increases may help children manage the challenges associated with learning and interacting with peers across a long day.

General Method

Cortisol Collection, Processing and Assay Procedures

Saliva samples were collected in the classroom setting by research assistants and at home by parents (for weekend samples). For afternoon samples taken from children in half-day programs, research assistants collected the samples where the children spent their afternoons (at home with a parent for all but four children). Saliva samples were collected at

approximately 10am and 4pm from up to three child care days and two weekend days per child.

One classroom in Study 1 (three children) and one classroom in Study 2 (six children) had unstimulated saliva samples collected via 1.5in cotton dental roll that was then expressed into a vial. For all the remaining classrooms in Study 1 ($N = 17$, 115 children) and Study 2 ($N = 9$ classrooms, 72 children), samples were collected with synthetic salivette collection devices (Sarstedt, Nuembrecht, Germany). It has been shown that cotton fibers retain cortisol particularly with low volume (de Weerth et al., 2003). To allow for inclusion of the samples collected with cotton rolls, the values were corrected by a factor of 1.4 nmol/L based on retention of known cortisol concentrations using cotton rolls from the same lot used in the study.

Saliva was extracted by centrifuging for 4 minutes at 2500 RPM. Vials and salivettes were frozen at -20°C until data collection was complete. Samples were then defrosted and batched for assay in groups of 36 and were assigned to batches so that classroom and batch were not confounded, and so that all samples from the same child were analyzed in the same batch. Samples were sent to the Biochemical Laboratory, Psychobiology, University of Trier, Germany to be assayed. Cortisol levels were determined using a competitive solid phase time-resolved fluorescence immunoassay with fluorometric end point detection (DELFI; Hoferl, Krist, & Buchbauer, 2005). The mean interassay coefficients of variation (CV) for controls were 6.6–8.5%. The intraassay CV for duplicates of samples used in these analyses was 5%.

All cortisol assays were performed in duplicate and averaged, resulting in two values per day (approximate 10 am and 4 pm) for up to three child care days and two home days. The average saliva collection times for morning and afternoon samples were 10:00 am ($SD = 12$ min) and 3:25 pm ($SD = 32$ min) and 9:50 am ($SD = 13$ min) and 4:06 pm ($SD = 19$ min), for Study 1 and Study 2 respectively. Cortisol values were reasonably normal, so no log transformation was performed. A total of 26 individual samples (3.4% of all samples) were excluded because their value was greater than $3SD$ for that specific time point within the sample and contamination was suspected.

Family and Demographic Characteristics

All participants were recruited as part of a larger study. The larger study had as a primary goal the purpose of examining cortisol patterning differences in different program structures as analyzed here with the full sample of children who provided cortisol data on both home and child care days (196). Other aims addressed the role of attachment to parents and teachers for children's cortisol patterns at child care (Badanes, et al., 2012), predictors and correlates of very low (attenuated) cortisol (Badanes, et al., 2011; Hankin, et al., 2010) and the special stresses and buffers among recent immigrant families (McFadyen-Ketchum, et al., in press). All participants from the larger study who attended a center or program that offered more than one program structure were included in the current studies. Information for demographic variables was gathered from parents and teachers. Parents were asked to report their child's birth date; their child's race using NIH categories (reported in Table 1, in analyses coded 1=minority race/ethnicity, 0=white/Caucasian and non-Hispanic). Age was

calculated by subtracting the child's birth date from the first saliva sampling date. Parent information was not available for age calculations for 20 children in Study 1 (13 full-time children) so teacher responses for child's age were used for calculations instead. Parent-reported birth dates were available for all participants in Study 2. Parents were also asked to complete a general health questionnaire about their child. This questionnaire included items asking about asthma, allergies, illnesses, use of an inhaler and other medical issues. These data were used to exclude children with illnesses during study participation and to exclude children using any medications known to interfere with cortisol assay (e.g., albuterol; see participant section for exclusions). Parents were also asked answer questions from the Family Finances questionnaire adapted from the NICHD Study of Early Child Care (2000), which consisted of one item addressing family size, two items assessing sources of income, one question asking about the amount of income earned, and five items asking about economic hardship (insecurity of critical resources, e.g., electricity) adapted from Conger and Elder (1994). This measure was used here for group descriptive purposes.

Procedure

The same procedure (previously described in Badanes et al., 2012) was used for all of the children attending full-day programs in both studies with a slight modification to the procedure for the half-day participants in Study 1. Briefly, trained RAs were present in the class prior to sampling to ensure that samples were collected at least 30 minutes after eating, at least 30 minutes after nap, and to ensure that samples were collected on 'typical' classroom days (i.e., not on days which included a class field trip or fire alarm etc.). Children in half-day Head Start programs were sampled by research assistants in their classroom in the morning and wherever they were at the matched time in the afternoon. For all but four children, this was at home with a parent. The target collection times were 10am and 4pm; however, times varied somewhat so as not to disrupt typical daily routines within the classroom.

On each sampling day, children's temperatures were obtained using a GeniusTM 2 IR Tympanic Thermometer. Samples on days when children's temperatures were over 99°F were not included in any analyses. If children were absent from child care due to an illness, sampling was delayed for at least two days after their return *and* all symptoms had cleared to collect samples again. Arrival and departure times were collected to ensure samples were collected on 'typical' days for each child by program type (i.e., if full-time, on a day where they attended for 7+ hours; see results). Children's height and weight were also collect by the research team so that children's body mass index (BMI) could be calculated.

Home weekend samples for all participants were collected by a parent. A diary was given to parents to remind them to wait at least 30 minutes from wake-up or eating before sampling. Parents were asked to mark down the sample time on each saliva vial, and compliance boxes were used to confirm the recorded time of samples. Compliance information was available for over 90% of parent collected samples, with the median difference between reported times and verified times being 3 minutes. For home samples collected by a trained RA (afternoon samples in half-day children in Study 1), the RA would verbally verify that the child had not eaten or slept within the last 30 minutes before collecting the sample.

All protocols were approved by the Institutional Review Board at the University of Denver. Families were compensated \$55 for their participation, while teachers were compensated \$20 for each child participating in their classroom, and a classroom gift of \$100.

Preliminary Analyses

Study 1 enrolled participants from Head-Start-funded programs that offer full-day and half-day programs, whereas Study 2 enrolled children from tuition-funded centers that offered full-time and part-time slots. Thus, we first conducted analyses that establish comparability of these four hypothesized different groups of children. Table 1 presents participant breakdown on the demographic variables across the four comparison groups. For each comparison, the percentages and means for the four groups were compared with a χ^2 analysis (for categorical variables) or an ANOVA (for continuous variables). For variables with significant group differences, we followed up with pair-wise comparisons. There were no overall differences for gender composition, or mean body mass index (BMI) across the four groups. There were, however, significant differences between the two Head Start and the two tuition-funded groups on all other variables. Head Start groups had more families experiencing economic hardship than did the tuition-based groups. This difference is not unexpected considering the eligibility for enrollment for Head Start families require proof of financial strain. In addition, Head Start centers had a higher portion of families that were Hispanic and that were primarily Spanish-speaking families than did tuition-funded programs. Finally, participants from Head-Start-funded centers were slightly older (by about half a year) than participants in tuition-funded centers. Given the differences between the Head Start vs. the tuition-funded centers, we proceeded with two sets of analyses – one comparing the full-day and half-day programs within the Head-Start-funded centers (Study 1), and the other comparing the full-time and part-time programs within the tuition funded centers (Study 2). The only difference between groups within Study 1 or Study 2 is that in Study 1, half-day Head Start families were more likely to be monolingual Spanish-speaking than were full-day Head Start families.

Data from 96 (49%) of the 196 children included here (31/37 [84%] of the tuition-funded full-time children, 16/41[39%] of the tuition-funded part-time children, 49/55 [89%] of the Head Start full-day children, and none of the Head Start half-day children) were included in a prior publication about the buffering role of attachment to teachers with regard to rising cortisol across the child care day (Badanes et al., 2012). The prior paper used data from all available children attending full-day child care at least three days per week at the time of analyses, while this paper includes additional children who were recruited to address the current question about program structure.

Analytic Plan

Given that cortisol was assessed twice a day on multiple days, our cortisol modeling choices were limited to (1) using a change score or (2) modeling a linear daily cortisol change while treating the day-to-day cortisol variability as a source of variability for computing the equation of the line. Both approaches have limitations. The use of difference scores has received considerable criticism, such as their unreliability and regression to the mean. However, analysis of change scores is mathematically equivalent to a repeated-measures

ANOVA and a paired *t*-test (Anderson et al., 1980), and a number of studies show that many concerns regarding change scores are unfounded (Cribbie & Jamieson, 2000; Edwards, 2001). The second approach (i.e., multilevel modeling of linear change in cortisol based on only two daily cortisol assessments) is controversial as it does not decompose the level-1 error in estimating the linear cortisol change and the level-2 variability that can be attributed to daily variations in cortisol diurnal patterns. This approach would have been acceptable if there was no day-to-day variability in the diurnal cortisol patterns. However, given that one of the aims of this study is to identify how attending different types of child care is associated with daily differences in cortisol diurnal patterns, we elected to follow the more conservative change score approach. We conceptualized the outcome variable as the amount of decline in cortisol from morning to afternoon values. The cortisol change score was calculated for each day as the morning value minus the afternoon value, with larger positive change scores indicating a greater cortisol decline and larger negative values indicating a larger cortisol increase throughout the day. Because morning cortisol values are tied to the amount of cortisol change that can happen throughout the day (i.e., higher morning values being linked to higher possible decline), all models controlled for the effect of morning cortisol values on the cortisol change.

Multilevel modeling (Snijders & Bosker, 1999) was used to estimate two-level models that predicted change in cortisol values across the day. The models accounted for clustering (nesting) of observations within an individual – as each participant had a cortisol change score and its daily predictors assessed on up to five days. At level 1, the model predicted cortisol change on each study day from other day-level variables – i.e., cortisol change for an individual *i* on day *d* (Cortisol Change_{*di*}) was modeled as a function of morning cortisol values (β_{1i}), time elapsed between the morning and afternoon cortisol collections (β_{2i}), and sampling location (β_{3i}). The time between cortisol collections variable adjusted results for differences in cortisol collection times (with larger periods of time being associated with larger cortisol change scores). The sample location variable estimated the effect of being at child care (coded as 1) versus at home (coded as 0) on cortisol change with the expectation that being at a child care facility would be associated with a lower cortisol change score (lower decline from morning to afternoon, flatter pattern) as compared to being at home.

Level 1:

$$\text{Cortisol Change}_{di} = \beta_{0i} + \beta_{1i} \text{ Morning Cortisol}_{di} + \beta_{2i} \text{ Time between cortisol collections}_{di} + \beta_{3i} \text{ Sampling location}_{di} + r_{di}$$

Level 2:

$$\begin{aligned} \beta_{0i} &= \gamma_{00} + \gamma_{01} \text{ Gender} + \gamma_{02} \text{ Age} + \gamma_{03} \text{ Minority Status} + \gamma_{04} \text{ Program structure}_i + u_0 \\ \beta_{1i} &= \gamma_{10} + u_1 \\ \beta_{2i} &= \gamma_{20} + u_2 \\ \beta_{3i} &= \gamma_{30} + \gamma_{31} \text{ Program structure}_i + u_3 \end{aligned}$$

At level 2, the model estimated the effects of child-level variables on the cortisol change score. Specifically, we were interested in modeling the effect of program structure (full-day/full-time vs. half-day or full-day/full-time vs. full-day/part-time) on daily cortisol change,

and in testing whether this effect interacted with the sampling location (i.e., is the effect of program structure influencing cortisol change on child-care days only, or is it present on both child-care and home days?). To answer the former, cortisol change intercept β_{0i} (i.e., cortisol change adjusted for level 1 variables) was modeled as a function of program structure (γ_{04}). To answer the latter, the effect of sampling location β_{3i} was also modeled as a function of program structure (γ_{31}), interpretable as a cross-level interaction between the sampling location and program structure variables. The models also controlled for gender, age, and race/ethnicity.

All predictors were grand-mean centered. Because the outcome variable (cortisol change) was computed as morning cortisol value minus afternoon cortisol value, positive regression coefficients can be interpreted as effects that increase the magnitude of morning to afternoon decline, whereas negative coefficients can be interpreted as effects that contribute to a flatter or rising cortisol pattern.

Study 1

Since the middle of the 20th century, following insights into the beneficial impacts of early stimulating experiences, there has been public interest in utilizing early child care settings as interventions (Bronfenbrenner, 1974). The goal of early intervention projects is to target those children at high risk for poor developmental outcomes, based on family income and maternal education level, and to try to alter their developmental trajectories early in life with additional supportive experiences. The overwhelming consensus is that early intervention programs can make a difference for children's outcomes (for a review of the benefits of intervention programs see Anderson et al., 2003; for a more general discussion see Shonkoff & Phillips, 2000), and data from the NICHD Study of Early Child Care and Youth Development (SECCYD) support the need for these interventions as children with both low-quality child care environments and disadvantaged home environments showed evidence of a double jeopardy effect –particularly for poor socio-emotional outcomes (Wataamura, Phillips, Morrissey, McCartney, & Bub, 2011). Today, Head Start is the leading U.S. federally funded early intervention program, serving nearly a million families in 2013 (Head Start Office of the Administration for Children and Families Early Childhood Learning, & Knowledge Center, 2013).

Although Head Start was traditionally a half-day program, there has been a move toward providing full-day and full-time care. According to the Head Start-Child Care Partnership Study (Kagan, Verzaro-O'Brien, Kim, & Formica, 2000), three factors have influenced Head Start programs to expand from their traditional half-day programming: 1) the increased need for longer hours of care as a result of increased school and labor participation subsequent to welfare reform, 2) increased linkages between Head Start and local early childhood education systems, including sources of funding and programming at the state level, and 3) the belief that full-day programming, along with Early Head Start, might increase the effectiveness of Head Start in preparing children for school. In fact, the Head Start Family and Child Experiences Study found that children in full-day Head Start classes showed larger gains in letter recognition and early writing skills than did children in half-day classes (Zill et al., 2003). Interestingly, in the partnership study (Kagan et al., 2000)

programs in Oregon, New York and California that favored expansion to full-day programming also expressed the need to consider the psychological impact of full-day group settings on children.

It is clear that full-day child care programs provide increased opportunities and supports for parents, and it may also be the case that full-day programs are better able to support cognitive gains for children. However, in order to accommodate the different schedules of families, full-day centers are typically open for 10–12 hours per day. Many children thus spend very long hours at child care and experience transitions in caregivers, whose eight hour shifts end while children stay in care (U.S. Department of Labor, 2011). Thus it is possible that the length of the day and transitions in caregivers, which frequently accompany full-day care, may result in a toll on the child's coping resources, just as a long work day takes a toll on adults in the workforce. This toll may be reflected by rising salivary cortisol patterns at child care.

We had one primary hypothesis for this study. Given that previous research has suggested that the long hours spent in child care may be a contributing factor for flat or increasing cortisol at child care, and the fact that most children show a decreasing cortisol pattern across the day at home on the weekend, we hypothesized that the change across the day in cortisol on child care days would differ between the group of children enrolled in full-day Head Start programs as compared to the group of children enrolled in half-day Head Start programs (who were not at child care in the afternoon). Specifically we expected children in full-day programs would show less steep declines across the child care day (indicative of flat or rising cortisol) than children in half-day programs. We did not expect to see differences by program type in cortisol patterning on home days, therefore we hypothesized an interaction between program type and sampling location such that children attending full-day/full-time programs would differ from those attending half-day programs only on child care (but not on home) days.

Method

Participants—Participants for Study 1 were enrolled in one of 18 classrooms within one of two Head Start funded centers. Five of these classrooms offered only full-day attendance, 12 of these classrooms offered only half-day enrollment and one classroom had both full-day and half-day attendance. Parents of 145 children in these 18 classes consented to participation in our study. Of these 145 families, 127 were eligible for participation: (eight were excluded for pervasive developmental delays (PDD) or other chronic illnesses, and 10 were excluded due to use of steroid medications which can interfere with cortisol assay interpretation). Of the 127 children eligible to participate, two refused to participate and seven did not provide sufficient saliva samples to be included in analyses. Of the 118 children included in our analyses, 63 (53%) were enrolled in half-day programs. Children enrolled in half-day programs, on average, arrived to child care 22 minutes earlier than children enrolled in full-day programs (arrival time = 8:03 AM ($SD = 14$ min) for half-day programs and arrival time = 8:25 AM ($SD = 31$ min) for full-day programs, $t[108] = 4.77$, $p < .001$) and stayed at child care for a shorter period of time (time = 3.4 hours [$SD = 14$ min] for half-day programs and time = 7.0 hours [$SD = 1$ hr 2 min] for full-day programs, $t[84] =$

23.00, $p < .001$). As discussed in the general method, for each day of data collection, a change score was created, and we attempted to sample children on three child care and two home days. In Study 1, 48, 44, and 8% of children had three, two, or one day of child care cortisol data available respectively, and 79 and 21% had two or one day of home cortisol data available respectively. Cortisol values did not differ as a function of the number of days of data collected (results available from the corresponding author). Please see Table 1 for demographic characteristics of half-day vs. full-day participants. Note that half-day vs. full-day Head Start participants differed (from each other) only on primary language. In additional models not presented here we also controlled language and the main findings were unchanged (available from the corresponding author upon request).

Results and Discussion

As can be seen in Table 2, older children showed greater cortisol declines across the day, $\gamma_{02} = .03$, $p < .001$. Those with higher morning values of cortisol were also more likely to show greater decreases in cortisol across the day, $\gamma_{10} = .75$, $p < .001$.

As expected, there was a main effect of sampling location (classroom = 1 vs. home = 0), $\gamma_{30} = -.03$, $p < .01$. As can be seen in Figure 1A, children had a greater cortisol decline on days they stayed at home and a flatter (or increasing) cortisol profile on the days they attended child care. By comparison, Figure 1B portrays raw cortisol scores that were not adjusted for differences in morning cortisol values (as well as assessment times and demographics) and similarly demonstrates declining patterns of cortisol on home days and flatter cortisol change on child-care days. This finding replicates previous work that demonstrates a flat or rising cortisol pattern on days when children attend child care.

Overall, children who attended full-day/full-time care (as compared to those who attended half-day care) had smaller cortisol declines, $\gamma_{04} = -.02$, $p < .05$. The effect of program structure did not interact with the effects of sampling location, $\gamma_{31} = -.02$, n.s. Thus, children attending full-day care had smaller cortisol declines (as evinced by a flatter or increasing cortisol profiles) on both child care and home days.

As an alternative to testing the effects of full-day vs. half-day care on cortisol, we also investigated the effects of actual attendance hours on cortisol. For this analysis, average attendance hours were calculated across the three child care data collection days. Using this continuous variable allowed us to test the dose-response effect of child care on daily cortisol patterns. Those who attended half-day care attended on average 3.4 hours of child care per day and those who attended full-day care attended on average 7.0 hours of child care per day. Results of multilevel modeling with hours in attendance as opposed to the full-day/half-day categorical variable revealed estimates that are very similar to the ones obtained with the categorical full-day/half-day coding. More hours in care were associated with flatter cortisol patterns, $b = -.02$, $p < .05$, and hours in care did not influence the effect of sampling location on cortisol change, $b = -.01$, n.s.

Study 2

Study 2 examined the impact of attending child care on a part-time (2–3 full days/week) as compared to a full-time (5 days/week) basis on preschoolers' diurnal cortisol patterning. Given that time spent in child care may have both positive and negative associations which may be dose-dependent, it is important to examine the effects of program structure on child outcomes. Additionally, if part-time attendees show a more normative physiological cortisol pattern, it may warrant more centers offering a variety of program structures for their families. For Study 2, we hypothesized that children attending full-day child care programs on a part-time basis would be equally or more likely to show flat or rising cortisol patterns across the day because they are still in child care for long hours, but have less time overall to acclimate to the setting. This hypothesis is clearly speculative; however, and it could certainly be the case that fewer hours of care across the week is less challenging regardless of whether individual days are long. As with Study 1, we hypothesized an interaction between program type and sampling location such that full-day/full-time children would differ from full-day/part-time children on child care but not on home days.

Method

Participants—Participants were enrolled in one of 10 classrooms within one of three community centers funded primarily through tuition. All classrooms offered both full-time and part-time attendance options. For the sake of clear comparisons, this study defined full-day/part-time attendance as attending either 2 or 3 days/week for at least 7 hours per day and full-day/full-time attendance as attending 5 days/week for at least 7 hours per day. No programs in Study 2 offered four days per week attendance as a program option. Parents enrolled 105 children from these classrooms into our study. Of the 105 enrolled, 78 children were included in the final analyses. A total of 27 children were excluded from the analyses; for PDD or chronic illness ($N = 7$), steroid medications ($N = 12$), refusing to participate ($N = 1$), being enrolled in the class for <3 months ($N = 1$), and irregular attendance that resulted in insufficient data ($N = 6$). Of the 78 final participants, 37 (47%) were enrolled full-time. Children enrolled in part-time and full-time programs, on average, arrived to child care at similar times (arrival time = 8:38 AM ($SD = 20$ min) for part-time programs and arrival time = 8:29 AM ($SD = 29$ min) for full-time programs, $t[75] = 1.63$, n.s.) and stayed at child care for a similar period of time (time = 8.2 hours [$SD = 31$ min] for part-time programs and time = 8.5 hours [$SD = 46$ min] for full-time programs, $t[73] = 1.96$, n.s.). In Study 2, 63, 30, and 7% of children had three, two, or one day of child care cortisol data available respectively, and 76 and 24% had two or one day of home cortisol data available respectively. Cortisol values did not differ as a function of the number of days of data collected (results available from the corresponding author). Please see Table 1 for demographic characteristics of full-day/full-time vs. full-day/part-time participants.

Results and Discussion

Table 3 demonstrates that those with higher morning values of cortisol were more likely to show greater decreases in cortisol across the day, $\gamma_{10} = .77$, $p < .001$. Similar to the findings of Study 1, there was a main effect of sampling location (classroom=1 vs. home=0), $\gamma_{30} = -.04$, $p < .01$ (see Figure 2).

Program structure was associated with cortisol change, $\gamma_{04} = -.03, p < .05$. As can be seen in Figure 2A, children who attended full-time care did not experience a decline in cortisol at home or at child care, whereas those who attended part-time care experienced a decline in cortisol throughout the day on home days. By comparison, Figure 2B portrays raw cortisol scores that were not adjusted for differences in morning cortisol values (as well as assessment times and demographics) and similarly demonstrates declining patterns of cortisol on home days and flatter cortisol change on child-care days. Program structure did not interact with sampling location, $\gamma_{31} = .01$, n.s. Children attended for nearly identical (8.2 vs. 8.5) number of hours on days they attended child care; therefore we did not repeat the analyses by hours of care in Study 2.

General Discussion

These studies suggest that program structure (or total hours in child care) may be an important consideration when examining the impact of child care on children's cortisol patterning. The findings suggest that the long hours many children spend in child care settings may be a contributing factor to the flat or rising cortisol patterning frequently observed, and indeed may also carry over to days spent at home.

Although there are several reasons why many preschool programs may choose to offer only full-time, full-day child care services, these studies provide at least initial support for the benefits of other program structures. Our results found for both studies that children enrolled in fewer hours of child care per week (half-day and full-day/part-time enrollment) were less likely than their full-day/full-time counterparts to show flat or rising cortisol patterning across the day at child care and at home. This suggests that the length of time children spend in these settings may be at least one contributing factor to the elevated cortisol patterning often reported in preschool aged children. As Kagan and colleagues (2000) noted, the reasons driving increased use of full-time programs within Head Start programs were family need to fit with work schedules, funding requirements, and the belief that more time spent in the child care setting might result in increased effectiveness of the program. Our findings suggest that half-day and part-time programs may be less physiologically demanding for children than full-day/full-time care, which may be an important consideration for some children.

We believe this study is the first to directly compare whether patterning across the day differs on home and child care days as a function of a program characteristic (in this case structure or hours). Many of the previous studies on this topic have included a comparison of children's cortisol patterning on home days, and these data have routinely indicated more normative (declining) cortisol on home days when compared to child care days (Groeneveld, et al., 2010; Watamura, et al., 2009; Watamura, et al., 2010; Watamura, Donzella, Alwin & Gunnar, 2003). Further, in two studies evening cortisol was nearly identical on home and child care days, suggesting a return to a normative pattern even after spending the full day at child care (Sumner et al. 2010; Watamura et al., 2009). Based on previous work, we expected to see an interaction between program type and sampling location such that children in full-day/full-time programs as a group would show flatter or rising cortisol on child care days when compared to children in part-time or half-day care, but that these

differences would not extend to home days. However, the expected interaction was not found – and in these studies differences between children in full-day/full-time care do in fact extend to weekend days spent at home. It is still the case, as in previous work, that for all groups of children, child care days elicit more flat or rising cortisol than do home days, but full-time/full-day children also show flatter cortisol production on home days. Of course, these studies were not experiments and children were therefore not assigned to different program structures. As described in the method, some family characteristics did differ across groups, though in all cases but one (family language), differences were between Head Start and non-Head Start families and not between the program structure groups statistically compared (see Table 1). Nevertheless, unmeasured family or child characteristics could play a role in what type of program structure is selected and therefore perhaps explain the fact that children in different program structures differed even on home days. One characteristic that could differ and potentially help explain these findings are differences in napping. If a child, for example, was already napping later in the afternoon and therefore parents chose full-time care, or if the child began napping later after beginning full-time care and/or engaged in compensatory napping on weekend days, we might have caught them (as a group) at a different point in their nap awakening response both on child care and home days. As is the practice in this literature, we verified that children had been awake for at least 30 minutes prior to sampling (and many children would have been awake longer or not have slept). However, in young children, afternoon naps can result in elevated cortisol levels for 45 minutes or longer (Gribbin, Watamura, Cairns, Harsh, & LeBourgeois, 2011), so if full-day/full-time children in both Head Start and tuition-funded programs were as a group sleeping later or longer both at child care and at home, this could have been a contributing factor. Unfortunately, we were not able to assess this possibility comprehensively in both studies because we did not measure sleep in half-time children or in the full sample of full-day/full-time or full-day/part-time children.

Another explanation is that the flatter cortisol seen on weekend days for children enrolled in full-day/full-time programs is in fact a carryover effect, reflecting a more sustained change in cortisol patterning as a result of full-day child care attendance. In previous work, we and others have reported that while children in child care show flatter or rising cortisol on child care days they generally do not show this pattern at home, with perhaps no more than 35% of children showing flat or rising cortisol at home within previous full-day samples (Watamura, et al., 2003; Watamura, Sebanc, & Gunnar, 2002). In this previous work, we did not, however, examine whether program differences (for example quality of care) predicted differences in at-home cortisol, and this literature in general has typically not used multi-level modeling to allow within-child variance to be modeled separately and simultaneously from between-context variance. In light of the current findings, a re-examination of these previously published data using multilevel modeling to examine whether key program, relational or child characteristics result in at-home differences may be worthwhile (Badanes, et al., 2012; Dettling, et al., 2000; Watamura, et al., 2003; Watamura, et al., 2009). However, even if a reanalysis of previous samples replicated home differences, it would be unclear whether characteristics of families were driving both the patterning differences and the choice of program or if true carryover effects were responsible for the differences.

One question is whether the differences are due to program structure, per se, or simply to hours spent in care. In Study 1, if we examine the average length of the day for each child the results replicate those found when comparing children by program structure type (half-day vs. full-day). This suggests that at least in this study actual usage by parents mirrored program offerings. We did not conduct similar analyses by hours of care in Study 2, as part-time children attended for nearly identical hours on the days they attended as did full-time children. Of course, one option may be for parents to utilize fewer hours of care; however, we elect to focus on program structures as that is the choice that programs and parents face, and if parents elect (and are able) to utilize fewer hours than the program offers, they are still required to pay for the full program. In our view, the policy change that would maximize benefits for children while minimizing costs would be to offer families more part-time and half-day options rather than putting the burden on families to pay for and then not utilize more extensive programming. Ideally, a decision could be made about the best program fit on an individual child basis, taking into consideration the full constellation of the child's cognitive, socio-emotional, physical, and psychological needs at that time and recognizing that these needs could certainly change with age. Another possibility when families need full-day and full-time care would be to evaluate whether pairing a high-quality stimulating morning program with a more relaxed higher adult-child ratio afternoon could support children not yet ready for a typical full-day.

The most difficult question to answer in this literature is what the consequences might be of exhibiting a non-declining cortisol pattern on child care days. Unfortunately, the potential consequences of cortisol patterning differences across the day while at child care vs. at home have been rarely examined. In one study, elevated cortisol at child care was associated with decreased antibody production on the following weekend (Watahara et al., 2010) suggesting that for at least some children, the challenges they face at child care and their means of coping with them take resources away from other important processes, including immune processes. Even with better evidence, a simple answer may also not be possible. These complex physiologic systems are understood to be in place for the protection of the organism, broadly speaking, and they respond to many types of challenges including cold temperatures and illness, as well as psycho-social stressors and challenges. Further, what activates stress physiology for one individual is not the same as what activates it for another, or even for that same individual at a different point in time. Instead, when the challenge exceeds the available coping resources, stress physiology may be recruited to help the individual manage the challenge. As children age, they find child care less challenging – and our results suggest this is also true when they are at child care for fewer hours. Perhaps as children age, and when they are in fewer hours of care, they are able to use other means of handling the challenges at child care such as behavioral and cognitive control. Similarly, some children may be better able to rely on adult buffering or perceive the challenges more positively even at a younger age. Of course, challenges themselves are inherent to growth, and it may certainly be possible that children reap cognitive and socio-emotional benefits from attending child care *and* recruit their stress physiology more in that environment, either transiently, or even to such an extent as to take resources away from other important processes. To properly address this question would likely require both random assignment to care environments and longitudinal assessments of a broad array of outcomes.

Taking the full picture of available data on young children, we feel it is likely the case that attending long hours of child care requires the support of stress physiology for some children while they grow and adapt. Because a number of studies show a more normative pattern on home days, and even in the evening on child care days, the HPA-axis may not be compensating for this repeated activation (e.g., with low levels in the morning, or with flat and low overall levels). If the child's HPA-axis is not making broader compensatory changes, this would lead us to believe that the recruitment of stress physiology in this way is not necessarily or inherently problematic. We caution, however, that when coupled with other indicators that the context is overwhelming, for example, when children repeatedly fall asleep in the car on the way home, skip dinner and sleep through the night or when children are constantly ill with very similar symptoms (not clearing infection), parents should be supported in limiting the number of hours children attend non-parental care until they are mature enough to benefit from the opportunities child care can provide by policies and programs that make this possible.

Limitations

There are several limitations to the current studies that should be noted. First, due to differences in funding sources and families served by the programs in our study, we felt that it would be inappropriate to directly compare the part-time and half-day groups. Additionally, due to the nature of our study populations, our findings may not be generalizable to other populations (for example to non-Hispanic Head Start attendees). To address these issues, future research should include larger sample sizes with a wider range of demographic variability. Importantly, due to the correlational nature of these studies and the lack of random assignment to classrooms, we cannot preclude the possibility of an extraneous variable driving these findings despite our best efforts to recruit appropriately matched populations. In particular, our two Head Start samples were much more likely to be of Hispanic ethnicity and Spanish-speaking, and to have higher family financial risk (as this is related to Head Start eligibility) and to be older than were children in tuition funded programs. Even within Head Start, the children enrolled in half-day programming were more likely to be monolingual Spanish speakers than were their full-day counterparts (but there were no other differences between Head Start attendees). Due to these sample confounds, we were not able to assess whether these family factors (rather than program structure) accounted for cortisol patterning differences. However, family factors would not explain home-to-child-care differences exhibited across all four groups of children.

In our geographic region, there were not sufficient programs offering both half-day and full-day slots *within* the same classrooms precluding the ideal analytic approach of using a 3-level model to estimate classroom level effects in Study 1. For part-time children in Study 2, slots were within classrooms; however, we had insufficient units of analysis for a 3-level model. In both Study 1 and Study 2, children were compared in groups closely matched (the same centers in Study 1, and the same classrooms in Study 2).

With regard to methodology, while it is, in general, our practice to fit children with actigraphs in order to control wake times wherever possible (and assess sleep), sufficient actigraphs were lost in the first classroom of half-day children to preclude this type of

expensive data collection. In our experience, even very high risk families can be fitted with these expensive devices without costly losses; however, this has only worked for us in protocols where we have planned regular contact with families that allows us to first properly explain the need for the equipment and then retrieve it. We do not believe that relying on parent-reported wake-times is helpful when the populations to be compared are very different. Therefore, an important limitation here is the lack of control for wake times, which could have differed at the group level across program types. If children in *both* half-day and part-time programs woke later than both groups of full-day/full-time attendees *and* were sampled while their cortisol awakening response was still occurring (within 1 hour of wake up), this could cause a steeper decline across the day for these children due to higher morning samples. We do not believe this accounts for our findings here; however, as arrival times were very similar across groups (presumably later sleeping children would arrive later), the first sampling times were within 10 minutes of each other across classroom types and occurred at 10am (most 3- to 5-year-old children have been up for several hours by 10am), we controlled starting values, and we controlled for time between sampling.

Conclusion

The findings from these studies extend previous work on cortisol reactivity in preschoolers attending non-parental child care. The data suggest that program structure may play an important role when examining the physiological impact of ECE settings on children's development. Specifically, reduced hours spent in child care may reduce one potentially negative impact of that context. However, it is also important to balance these findings with other research reporting the cognitive gains made from increased time spent in early care centers. Perhaps some children benefit more from additional hours of non-parental care, while others benefit less, or perhaps children can acquire cognitive benefits while also recruiting their stress physiology to learn and grow while at child care.

Implications for Caregivers and Teachers

This work offers at least some initial evidence to consider the physiological implications of program structure for early care centers, although there are many other factors which must necessarily be considered (e.g., family needs). Additional work examining the physiological and behavioral correlates of program structure and the length of the child care day while simultaneously assessing cognitive impacts would certainly help inform this discussion. This work suggests that half-day and part-time programs may be an ideal way for children to gain, at least in part, the cognitive benefits of early child care without taxing their physiological abilities. However, it may be most appropriate to make placement decisions on a case by case basis taking into account the full picture of child and family needs and resources.

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Highlights

- Flat or Rising cortisol across the day has been associated with full-time child care
- Children in full-time (FT), part-time (PT) and half-day (HD) programs were compared
- In all program types, cortisol production was higher across child care vs. home days
- Children in tuition-funded FT vs. PT care had flatter cortisol at child care and at home
- Children in Head Start FT vs. HD care had flatter cortisol at child care and at home
- More hours of Head Start attendance was associated with flatter cortisol

Figure 1. Cortisol Change throughout the Day for Study 1 (Head Start) Participants; (A) Estimated Changes (Controlling for Morning Cortisol, Assessment Times, and Demographics); (B) Observed Unadjusted Mean (SEM) Cortisol Scores

Figure 2. Cortisol Change throughout the Day for Study 2 (Tuition Based) Participants; (A) Estimated Changes (Controlling for Morning Cortisol, Assessment Times, and Demographics); (B) Observed Unadjusted Mean (SEM) Cortisol Scores

Table 1

Demographic Differences among Children in the Four Types of Programs

	Study 1 (Head Start)			Study 2 (Tuition Based)		Overall differences χ^2 (d.f.)	Pairwise differences (Bonferroni adjusted $p < .05$)
	Full-day (FD)	Half-day (HD)	%	Full-time (FT)	Part-time (PT)		
Female	50.9	41.3	54.1	51.2		2.03 (3)	--
Race						131.65 (12)	
Hispanic	60	81	3	2			PT, FT < FD, HD
Caucasian-American, non-Hispanic	15	3	62	85			HD, FD < FT, PT
African-American, non-Hispanic	13	3	8	0			n.s.
Asian-American, non-Hispanic	0	0	5	2			n.s.
Bi-racial/Bi-ethnic	13	13	22	10			n.s.
Questionnaire in Spanish	53	84	0	0		105.1 *** (3)	FT, PT < FD < HD
Child's primary language						130.9 *** (9)	
English - monolingual	31	8	78	93			HD < FD < FT, PT
Spanish - monolingual	16	54	0	0			FT, PT < FD < HD
Spanish - bilingual	47	37	8	0			PT, FT < HD, FD
Other	6	2	14	7			n.s.
	Mean (SD)					F (d.f.)	
Age	4.41 (.65)	4.59 (.61)	4.06 (.70)	3.80 (.56)		16.25 *** (3, 190)	PT, FT < FD, HD
BMI	18 (12)	18 (12)	18 (14)	16 (1.6)		.41 (3, 177)	--
Economic Hardship	1.3 (1.5)	1.8 (1.3)	.44 (0.8)	.16 (0.2)		22.1 *** (3, 153)	PT, FT < FD, HD

 $p < .001$,**
 $p < .01$,*
 $p < .05$

Table 2
Effects of Full-Day vs. Half-Day Program Structure on Cortisol Change (Head Start)

Effect	B	SE
Fixed effects		
Intercept of Cortisol Change, β_0		
Intercept, γ_{00}	.03***	<.01
Gender, γ_{01}	-.004	.01
Age, γ_{02}	.03***	.01
Minority, γ_{03}	.02	.01
Program structure (full-time=1, half-day = 0), γ_{04}	-.02*	.01
Morning cortisol, β_1		
Intercept, γ_{10}	.75***	.06
Time between cortisol collections, β_2		
Intercept, γ_{20}	.003	.005
Sampling location (classroom = 1, home = 0), β_3		
Intercept, γ_{30}	-.03***	.01
Program structure (full-time=1, half-day = 0), γ_{31}	-.02	.02
Random effects		
Level 1 error, r		
Intercept, u_0	.06	
	.001**	
Morning cortisol, u_1		
	.29*	
Sampling location (classroom = 1, home = 0), u_3		
	.01	

 $p < .001$,

**
 $p < .01$,

*
 $p < .05$.

The reported coefficients are unstandardized.