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Individual differences in early adolescents' latent trait cortisol (LTC): Relation to recent acute and chronic stress

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ABSTRACT

Research suggests that environmental stress contributes to health by altering the regulation of the hypothalamic pituitary adrenal (HPA) axis. Recent evidence indicates that *early* life stress alters trait indicators of HPA axis activity, but whether *recent* stress alters such indicators is unknown. Using objective contextual stress interviews with adolescent girls and their mothers, we examined the impact of recent acute and chronic stress occurring during the past year on early adolescent girls' latent trait cortisol (LTC) level. We also examined whether associations between recent stress and LTC level: a) varied according to the interpersonal nature and controllability of the stress; and b) remained after accounting for the effect of early life stress. Adolescents ($n = 117$; M age = 12.39 years) provided salivary cortisol samples three times a day (waking, 30 min post-waking and bedtime) over 3 days. Results indicated that greater recent interpersonal acute stress and greater recent independent (i.e., uncontrollable) acute stress were each associated with a higher LTC level, over and above the effect of early adversity. In contrast, greater recent chronic stress was associated with a lower LTC level. Findings were similar in the overall sample and a subsample of participants who strictly adhered to the timed schedule of saliva sample collection. Implications for understanding the impact of recent stress on trait-like individual differences in HPA axis activity are discussed.

1. Introduction

Research suggests that sustained exposure to environmental stress "gets under the skin" thereby increasing risk for adverse health outcomes by altering multiple physiological systems, including the hypothalamic pituitary adrenal (HPA) axis (e.g., Juster et al., 2010; McEwen, 2004). This is true for various types of stress, including early adversity (i.e., childhood experiences) as well as more recent stressors such as acute life events and chronic difficulties (e.g., Dickerson and Kemeny, 2004; Doane et al., 2015; Miller et al., 2007). Despite this evidence, prior work has not addressed whether recent stress (i.e., stress during the past year) is associated with trait-like individual differences in HPA axis activity and whether its impact depends upon the nature of the stressor. The present study sought to address these gaps.

1.1. Recent stress and HPA axis functioning

Meta-analyses suggest that recent stress leads to alterations in basal activity (i.e., levels at certain times of day; e.g., morning cortisol), diurnal cortisol rhythms (i.e., the daily pattern of cortisol secretion) and cortisol reactivity (i.e., changes in cortisol levels in response to a stressor; e.g., Dickerson and Kemeny, 2004; Miller et al., 2007). Recent stress can take the form of: (a) stressful life events (i.e., acute stress; e.g., death, break-ups)—characterized by their acute onset and relatively brief duration; and (b) chronic stress (e.g., ongoing relationship difficulties)—characterized by its endurance over time. The impact of recent stress on HPA axis activity depends upon the interpersonal nature and controllability of the stress (e.g., Dickerson and Kemeny, 2004; Miller et al., 2007). For example, in laboratory studies of cortisol reactivity,

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acute stress tasks characterized by social-evaluative threat produced significantly greater cortisol levels than those without such threat (Dickerson and Kemeny, 2004). Furthermore, uncontrollable stressors tend to be associated with lower morning cortisol whereas controllable stressors tend to be associated with higher morning cortisol (Miller et al., 2007).

Despite this evidence, prior work has not addressed whether recent stress is associated with individual differences in trait cortisol and whether its impact depends upon the nature of the stressor. Moreover, little is known about the cumulative effect of recent stress (i.e., total exposure to multiple stressors) on HPA axis functioning, as prior work has predominately examined the impact of a singular stressor. Importantly, however, several studies indicate that youth exposed to multiple early stressors exhibit greater allostatic load, as reflected by sustained or altered activity in multiple regulatory systems, including the HPA axis (e.g., Evans et al., 2007; Repetti et al., 2002; Zalewski et al., 2012). Indeed, in the present sample, we demonstrated that the accumulation of nine types of early adversity was related to trait cortisol (Stroud et al., 2016). However, it remains to be investigated whether the accumulation of recent stress is related to trait cortisol.

1.2. Recent stress and latent trait cortisol

Longitudinal studies suggest that the cortisol indicators used in prior work examining the association between recent stress and HPA axis regulation exhibit limited stability and largely capture day-to-day or cross-wave fluctuations within individuals, rather than stable individual differences (e.g., Doane et al., 2015; Ross et al., 2014). Recently, researchers have modeled a latent trait cortisol (LTC) factor that captures stable individual differences in cortisol levels (e.g., Chen et al., 2015; Doane et al., 2015; Giesbrecht et al., 2015). For example, Doane et al. (2015) modeled LTC indicators in a sample of young adults, which were distinct from other diurnal indicators (i.e., cortisol awakening response [CAR]; diurnal slope), exhibited stability within and across three assessments, and largely reflected between-person variability in HPA activity.

Research has not examined whether the accumulation of recent stress contributes to LTC level, leaving a considerable gap in the literature: although we have substantial evidence that recent stress contributes to alterations in diurnal cortisol indicators (e.g., CAR, diurnal slope; Miller et al., 2007) that mainly capture day-to-day differences in cortisol levels within individuals (Doane et al., 2015; Ross et al., 2014), we know very little about whether recent stress contributes to enduring differences in HPA axis activity between individuals. Importantly, an investigation of the association between recent stress and LTC level permits the evaluation of whether recent stress contributes to allostatic states or alterations in the set points regulating HPA axis activity (e.g., McEwen, 1998)—one of the primary mechanisms through which stress negatively impacts health (e.g., Juster et al., 2010; Repetti et al., 2002). In addition, given robust evidence linking early life stress and alterations in HPA axis functioning (e.g., Doane et al., 2015; Trickett et al., 2011), as well as research indicating that early life stress may have a stronger impact on stress physiology than that occurring at later ages (e.g., Carpenter et al., 2004), it is important to examine whether recent stress influences LTC level after accounting for the impact of early life stress. Moreover, prior work indicates that children exposed to early life stress continue to experience higher levels of recent acute and chronic stress during adolescence (e.g., Harkness et al., 2006; Hazel et al., 2008); thus, it is critical to evaluate whether associations between recent stress and LTC level simply reflect the continuity of stress over time or the contribution of recent stress to LTC level, over and above the effect of early life stress.

1.3. The present study

This study expands upon a prior investigation in which we demonstrated that early adversity was associated with a LTC factor derived from two morning cortisol samples (waking, 30 min post-waking; Stroud et al., 2016). Here we built upon these findings by examining whether the *accumulation* of recent acute and chronic stress (occurring during the past year) were each associated with LTC level, and whether associations (a) depended upon the interpersonal status and controllability of the stress; and (b) remained after accounting for the effect of early adversity. Given prior work, we expected that recent acute and chronic stress would each be associated with LTC level, over and above the effect of early adversity, and that interpersonal status and controllability would modify associations.

2. Methods

2.1. Participants and procedure

Participants were early adolescent girls who completed the saliva sampling portion of a larger study examining biopsychosocial predictors of emotional disorders (total sample: $N = 132$).[1] Participants and their primary female caregivers (herein called "mother") were recruited from two New England counties through advertisements or flyers; word-of-mouth; and local schools. Five of the 122 participants who completed the saliva collection portion of the study with low levels of compliance (no valid 30 min post-waking samples; see compliance definition below) were excluded from analyses, resulting in a total of 117 participants (M age = 12.39 years, $SD = 0.77$ years; 88.9% White). Most families were middle to upper class (<$40,000 [18.8%]; $41,000–$60,000 [17.9%]; $61,000–$100,000 [25.6%]; > $100,000 [36.7%]).[2]

The college Institutional Review Board approved all procedures. During a laboratory visit, adolescents and their mothers completed assent and consent forms, respectively, and were invited to ask questions to ensure adequate understanding of study procedures. Subsequently, adolescents and their mothers completed interviews and questionnaires (including demographic and health questionnaires), and were provided instructions and materials for saliva collection. Approximately one week later ($M = 7.48$ days; $SD = 8.86$), adolescents collected whole saliva by passive drool 3 times per day (waking, 30 min post-waking, bedtime) on 3 consecutive weekdays, avoiding atypical days (e.g., vacations). For each sample, adolescents recorded the time and completed a diary assessment, which included questions assessing time of waking as well as affect, perceived stress, caffeine use, and nicotine use in the hour preceding sampling. Compliance was assessed with a MEMS 6TM (Aardex; Aardex Group, Richmond, VA) track cap. Samples were returned via mail; stored at −20 °C; and sent on dry ice to the Biochemisches Labor at the University of Trier, Germany to be assayed. On average 8.66 ($SD = 0.82$) samples were provided per participant and 87 (74.4%) used the track cap. Analyses were conducted with the full sample ($n = 117$) and with a subset of participants ($n = 69$) who strictly adhered to the timed schedule of saliva sample collection and used a track cap (see below).

[1] There were not significant differences between those who did and did not complete the cortisol assessment on child age, family income, pubertal status, recent stress or overall severity of early adversity ($ps > 0.10$).

[2] Four siblings of participants and two fathers participated in the study. However, all results remained the same when these individuals were excluded from the analyses.