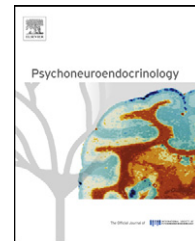




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SHORT COMMUNICATION

Neuroendocrine predictors of emotional and behavioral adjustment in boys: Longitudinal follow-up of a community sample

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Summary

Background: Dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis has been observed in adults and children with mood and anxiety disorders and is thought to be involved in the pathogenesis of these disorders. We recently studied a diverse community sample of boys and found associations of behavioral problems, including symptoms of depression and anxiety, with basal and stress-induced cortisol concentrations. Here we examine cortisol–emotional/behavioral associations at a two-year follow-up and test whether initial cortisol is predictive of worsening emotional/behavioral problems two years later.

Method: Seventy-eight 10–14-year-old boys and their mothers completed a battery of psychosocial assessments, provided morning and afternoon saliva samples, and participated in a home visit involving mildly stressful tasks and saliva collection for cortisol assay during a two-year follow-up assessment.

Results: Consistent with the findings from our time 1 assessment, greater declines in cortisol across the home-visit challenge task were significantly associated with internalizing and externalizing behaviors as well as attention problems and social problems at the two-year follow-up. In

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addition, morning and afternoon cortisol concentrations at the initial assessment were significant positive predictors of the later development of child depressive symptoms at follow-up after controlling for initial depressive symptoms.

Conclusion: These findings demonstrate that children in the community with internalizing and externalizing behavior problems have altered patterns of HPA axis stress reactivity. In addition, our prospective findings suggest that elevated cortisol concentrations may influence the later development of emotional/behavioral problems in boys.

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1. Introduction

Excessive activation of the hypothalamic–pituitary–adrenal (HPA) axis is seen in a substantial proportion of adults and children with depressive and anxiety disorders (Guerry and Hastings, 2011; Pervanidou, 2008). Youth with subsyndromal symptoms of depression and anxiety (internalizing symptoms) also show increased basal and provoked cortisol concentrations in several studies, whereas externalizing behaviors have been linked to blunted cortisol concentrations and responses in some reports. Other studies have documented elevated cortisol concentrations with externalizing behaviors, possibly due to the co-occurrence of internalizing and externalizing behaviors (Tyrka et al., 2010).

HPA axis dysfunction may lead to behavioral symptoms because glucocorticoid receptors (GRs), are widely distributed in limbic brain regions involved in the regulation of stress responses, cognition, affect, and behavior. Animal studies show that excessive or prolonged activation of GRs results in neurostructural changes in these regions (McEwen, 2007). Therefore, longitudinal studies of the association between cortisol activity and the later development of psychopathology are of great interest. Statistically controlling for the contemporaneous association between cortisol and emotional/behavioral problems at the initial assessment is necessary to show that cortisol is linked to the *later* development of emotional/behavioral problems.

Only a few prior investigations have conducted such prospective analyses, but the findings are suggestive of an effect of cortisol on the later development of emotional/behavior problems. In a study of 4.5-year-old boys, higher afternoon cortisol predicted the development of greater internalizing behaviors and social wariness in Kindergarten, after controlling for initial behavior (Smider et al., 2002). Elevated morning saliva cortisol in a sample of 13-year-olds predicted depressive symptoms at age 16, after controlling for initial depressive symptoms (Halligan et al., 2007). In a 6-month follow-up study of 7–17-year-old clinic-referred children, cortisol reactivity to a parent–child conflict discussion task was inversely predictive of later internalizing and externalizing behaviors, but positively predictive of anxiety disorders (Granger et al., 1996). Finally, in adolescents at-risk for psychopathology, high morning cortisol predicted onset of a major depressive episode in the following 12 months (Goodyer et al., 2000).

While most prior work on this topic has involved white, middle-class samples of preschool or adolescent-aged boys and girls, we recently found, in a study of boys, aged 8–11 from diverse backgrounds, that internalizing problems were linked to higher basal afternoon cortisol concentrations (Tyrka et al., 2010). Additionally, a greater decline in cortisol

concentrations across a home-visit challenge task was seen in boys with internalizing behaviors and social problems, as well as attention and thought problems. Here we report a two-year follow-up assessment in this sample to determine whether these associations persist. In addition, we hypothesized a prospective relationship between initial cortisol concentrations and later increases in emotional/behavioral problems at the two-year follow-up.

2. Methods

2.1. Participants

Boys aged 8–11 ($M = 9.10$, $SD = 0.73$) were recruited from several New York City area public schools and followed two years later (range = 1.5–2.5 years) when they were aged 10–14 ($M = 12.3$, $SD = 0.72$). One hundred two of these participants provided data for analyses of the association between cortisol measures and emotion/behavior at the time 1 assessment and were thus included in our initial report on this topic (Tyrka et al., 2010). The current study includes seventy-eight boys with follow-up cortisol and emotional/behavioral measures, including 61 who were included in our initial report (Tyrka et al., 2010), and an additional 17 who participated in the study initially but did not have complete cortisol and emotional/behavioral data at the initial assessment for inclusion in the prior report. The prospective analyses included 69 of these boys who had both the follow-up cortisol and emotional/behavioral measures as well as the initial emotional/behavioral measure that was controlled in the analysis.

The follow-up sample did not differ from the initial cohort at time 1 (T_1) on the demographic measures (Table 1). Those who did not participate at follow-up had higher self-reported depressive symptoms at T_1 ($p < .05$), but did not differ on any of the other emotional/behavioral measures.

2.2. Procedures

Methodological details are described in Tyrka et al. (2010). Briefly, boys and their mothers participated in a home visit stress paradigm involving four challenging tasks with saliva sampling at baseline and after each task. These visits took place between 4:00 and 8:00 PM ($M = 5:32$ PM, $SD = 1:16$). In addition, mothers and boys completed questionnaires and collected saliva samples at home on two consecutive days: a morning saliva sample immediately upon awakening and before brushing teeth or consuming anything, and an afternoon sample upon return from school. Cortisol concentrations from the two sampling days were averaged for the AM and the

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