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# Behavioral adjustment in a community sample of boys: Links with basal and stress-induced salivary cortisol concentrations

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**Summary** Dysregulation of the hypothalamic—pituitary—adrenal (HPA) axis has been observed in association with internalizing symptoms and is thought to be involved in the pathogenesis of depression and some anxiety disorders. This study examined basal and stress-induced cortisol concentrations in relation to internalizing and externalizing symptoms in a racially mixed community sample of 102 8—11-year-old boys. Afternoon basal cortisol concentrations were positively correlated with measures of internalizing behavior problems, social problems, and emotionality. Greater change in cortisol across a home-visit challenge task was also significantly associated with internalizing behaviors and social problems, as well as attention and thought problems. The implications of these findings and how they may relate to the pathogenesis of emotional and behavioral problems are discussed.


## 1. Introduction

Several decades of research document alterations of hypothalamic—pituitary—adrenal (HPA) axis function in association with depression and some anxiety disorders (Holsboer, 2000; Kaufman and Charney, 2001; Hasler et al., 2004; Risbrough and Stein, 2006). The HPA axis is involved in maintaining basic physiological functioning as well as coordinating neural, hormonal, and behavioral responses to stressors. Basal glucocorticoid levels follow a diurnal rhythm, with the highest concentrations in the early morning and the nadir in the late evening hours. This basal activity is necessary for normal brain growth and regulates metabolic processes needed for basic functioning. In addition, glucocorticoids

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are released in response to acute challenges and serve to mobilize energy resources and prepare the organism to respond to stressors (McEwen, 2007). Research on HPA axis function has examined both basal cortisol concentrations at various points in the diurnal curve and ''provoked'' or stress-induced changes in cortisol concentrations.

Increased basal and provoked cortisol concentrations have been shown in individuals with traits such as neuroticism and inhibition as well as internalizing symptoms (Kagan et al., 1987; Schmidt et al., 1997; de Haan et al., 1998; Smider et al., 2002; Zobel et al., 2004; Tyrka et al., 2007, 2008). It has been hypothesized that such differences are secondary to increased sensitivity to stress or lower thresholds for activation of the HPA axis and other stress-response systems. Prolonged exposure to elevated glucocorticoid concentrations may result in neurostructural changes in limbic brain regions, including neuronal cell death and inhibition of neurogenesis (Duman and Monteggia, 2006; McEwen, 2007). Thus, while acute increases in glucocorticoids can enhance memory, learning and emotional responding, prolonged or excessive elevations may lead to cognitive and affective disturbances.

Research on the association of HPA axis dysfunction in children and adolescents with internalizing disorders has yielded somewhat variable findings. Increased morning or evening cortisol concentrations have been reported in association with depression as well as other internalizing disorders in clinical samples of children and adolescents (Dahl et al., 1991; Goodyer et al., 1996; Rao et al., 1996; Gispen-de Wied et al., 2000; Goodyer et al., 2000, 2001; Mathew et al., 2003; Forbes et al., 2006). Other studies have shown increased cortisol reactivity in depressed children or adolescents in the dexamethasone suppression test or in response to a social challenge task (Tout et al., 1998; Luby et al., 2004). Two studies have shown high sensitivity but low specificity of the DST for identifying depressed children compared to children with other disorders (Targum and Capodanno, 1983; Petty et al., 1985), and two studies have found altered HPA axis function in depressed youth only when there was comorbid maltreatment. Several other investigations have not found evidence of increased basal or provoked cortisol concentrations in depressed youth (Geller et al., 1983; Ha et al., 1984; Dahl et al., 1989; Puig-Antich et al., 1989; Kutcher et al., 1991; Birmaher et al., 1992, 1996; Dorn et al., 1996; Luby et al., 2003).

Several studies have focused on broad measures of internalizing behavior problems in community samples of children and adolescents. Increased basal cortisol concentrations have been found in children with internalizing behavior problems in several investigations (Gunnar et al., 1997; de Haan et al., 1998; Tout et al., 1998; Cicchetti and Rogosch, 2001; Goodyer et al., 2003; Blair et al., 2004; Van den Bergh et al., 2008). However, other studies have found that lower cortisol activity is associated with internalizing behaviors and that higher cortisol may be linked to extroversion (Davis et al., 1999) or anger (Adam, 2006).

Challenge tasks have been designed to elicit cortisol responses with consideration of the ecological validity of the task and sometimes the context in which the task was administered. Increased salivary cortisol in children with internalizing symptoms has been shown in response to psychosocial challenge tasks (Tout et al., 1998; Luby et al., 2003) and the fear-potentiated startle paradigm (Ashman et al., 2002). Granger et al. (1994) used a parent—child conflict-discussion laboratory task with a sample of 102 7—17-year-old clinic-referred children. While the majority of subjects had decreases in salivary cortisol concentrations in response to the task compared to pre-task cortisol levels, those who had increases had higher levels of social withdrawal, social anxiety, and social problems. Klimes-Dougan et al. (2001) also used a conflict-discussion task during a home visit in their study of youths aged 11—17. As with the Granger study above, mean salivary cortisol concentrations decreased over the course of the task. Those youths who had a mild decrease in salivary cortisol over the course of the task had the lowest internalizing and externalizing scores, whereas those with higher internalizing and externalizing scores had either an increase or a strong decrease in response to the task. In addition, this study involved a social performance paradigm in which youths were instructed to talk with a shy person and then give a 3-min speech. Girls who had an increase in salivary cortisol in response to this task had higher levels of internalizing and attention problems.

In contrast to the literature demonstrating increased basal cortisol concentrations in association with internalizing behavior problems, several investigations have found children with externalizing behaviors to have low basal (Tennes and Kreye, 1985; Scerbo and Kolko, 1994; Cicchetti and Rogosch, 2001; Smider et al., 2002; Shoal et al., 2003; Shirtcliff et al., 2005) and stress-induced cortisol concentrations (van Goozen et al., 1998). Children with extroversion or externalizing behaviors may have higher thresholds for activation of stress-responsive physiological systems (Rogeness et al., 1990). On the other hand, externalizing behavioral problems are highly correlated with internalizing symptoms (Achenbach et al., 1991), and some evidence suggests that cortisol reactivity may be associated with both behavior patterns (Klimes-Dougan et al., 2001; Boyce et al., 2006), depending on contextual factors (de Haan et al., 1998; Gunnar et al., 2003) or comorbid symptoms (McBurnett et al., 1991; van Goozen et al., 1998; Cicchetti and Rogosch, 2001; Blair et al., 2004).

Most existing studies of the relationship between behavioral problems and cortisol concentrations appear to have been conducted in largely middle-class, White samples, although many studies have not provided information regarding these demographic factors. Race and ethnicity could be linked to stress reactivity and HPA axis function via physiological differences as well as disparities in stress exposure related to poverty, crime, and racism (Szanton et al., 2005). Racial differences in HPA axis function have been demonstrated in youths and adults. For example, lower morning cortisol concentrations (Bennett et al., 2004; DeSantis et al., 2007; Chong et al., 2008), lower cortisol responses to psychosocial stress (Mechlin et al., 2005; Chong et al., 2008) and higher evening cortisol values (Cohen et al., 2006; DeSantis et al., 2007) have been shown in some groups of Black youths and adults in comparison with Whites. One investigation also found higher evening cortisol concentrations among Hispanic youths in comparison to White youths (DeSantis et al., 2007). Socioeconomic status (SES) can also influence neuroendocrine activity (Lupie et al., 2001; Cohen et al., 2006). Social influences such as socioeconomic adversity or stress associated with discrimination might account for some of the