



## Salivary gonadal and adrenal hormone differences in boys and girls with and without disruptive behavior disorders: Contextual variants

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### ABSTRACT

Hormone differences by psychopathology group and gender may have implications for understanding disruptive behavior disorders (DBDs) and complexities of treatment outcomes. Current theoretical models emphasize contextual differences as moderators of hormone–behavior relations. This baseline report examined: (a) hormone differences in youth with and without DBD, and (b) contextual factors as moderators of behavior problems and hormones. 180 children and adolescents were enrolled (141 boys, mean  $9.0 \pm 1.7$  years). DBD participants met criteria for conduct disorder (CD) and/or oppositional defiant disorder (ODD) ( $n = 111$ ); 69 were recruited as healthy comparisons (HC). Saliva was collected for testosterone, cortisol, dehydroepiandrosterone and androstenedione. DBD youth had significantly higher androstenedione than the HC group. There was a group by gender interaction for basal cortisol mean with DBD boys and HC girls having lower cortisol. Moderating effects of contextual variables (e.g., family functioning, delinquent peers) were noted for cortisol and adrenal androgens. Findings argue for considering hormones as an influence on DBD beyond simple direct one-to-one associations.

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### 1. Introduction

Numerous reports reveal the significant toll that adolescent antisocial behavior takes on society as a whole as well as on families and individuals (Jones et al., 2002). Potential causative factors of antisocial behavior are less well examined. In a few studies, correlates and causes of antisocial or disruptive behavior disorders (DBDs), notably, oppositional defiant disorder (ODD) and conduct disorder (CD) have been centered on the influence of contextual factors. These include parent psychopathology (Kaplan and Liu, 1999; Tremblay et al., 2004), family/parenting environment including maternal parenting (Frick et al., 1992), hostility (Lahey et al., 1989; Rey and Plapp, 1990) and parent supervision and/or parenting behaviors and practices (Haapasalo and Tremblay, 1994; Stormshak et al., 2000). In all instances, parent psychopathology and negative parenting environments or lack of supervision is related to negative child and adolescent behaviors. Additionally, contextual correlates of DBD or antisocial behaviors

include involvement with deviant peers (Burke et al., 2005; Coie and Miller-Johnson, 2001; Dishion et al., 1995; Keenan et al., 1995) or peer rejection (Dodge et al., 2003) where more associations with deviant peers or peer rejection is associated with increased DBD. Stress related to family functioning also affects DBD (Mathijssen et al., 1999); specifically, family dysfunction is a risk for developing externalizing problems. Similarly, socioeconomic status (Loeber et al., 1995; Tremblay et al., 2004) and socioemotional factors, such as impulsivity, and arousal (Lahey et al., 1993; Vanyukov et al., 1993) may influence the onset or persistence of DBD. Importantly, such negative contextual factors typically are more prominent in DBD than non-DBD children (Kolko et al., 2008).

In addition to contextual factors, biological parameters, including the autonomic nervous system (ANS) and neurotransmitters, also have been examined in relation to DBD, although to a much lesser degree (see reviews Lorber, 2004; Stoff and Susman, 2005; and other empirical work (Kruesi et al., 1992; Mezzacappa et al., 1997; Raine, 1993; Scarpa and Raine, 2003). Such examination is based on the premise that these biological parameters may influence disruptive behavior. An increasing number of studies are now focused on neuroendocrine processes in DBD compared to healthy youth (for example, see van Goozen and Fairchild, 2006). Hormones may contribute to variations in DBD phenotype and subsequent outcome of treatment. Further,

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interindividual differences in hormone levels may be a cause or a consequence of DBD. Specifically, the hormone-related psychobiology of stress has been linked to behavior problems in youth (Stoff and Susman, 2005). Most studies examining DBD or externalizing problems focused on testosterone (T) (Book et al., 2001; Granger et al., 2003; Olweus, 1986; Popma et al., 2007; Scerbo and Kolko, 1994; van Bokhoven et al., 2006) and cortisol (McBurnett et al., 2000; Pajer et al., 2001a; Popma et al., 2007; Susman et al., 1997). DBD and externalizing problems have been shown to be related to aggression and low arousal, respectively. However, the direction of these relations is not always uniform (e.g., Booth et al., 2003) or is not always different from non-DBD participants (Granger et al., 2003; Rowe et al., 2004; van Goozen et al., 1998). To our knowledge, examination of disruptive behavior and diurnal changes in hormones, particularly cortisol, has received less attention. Diurnal changes in cortisol may represent a vulnerability to antisocial behavior (Susman et al., 2007) and differences in the typical diurnal pattern of cortisol may also vary with contextual factors (Watamura et al., 2003).

Individual differences in adrenal androgen levels including dehydroepiandrosterone (DHEA), its sulphate (DHEAS) and androstenedione, have received much less attention with regard to DBD. Exceptions include van Goozen and colleagues who reported high DHEAS in DBD boys and no differences in androstenedione between DBD and healthy boys (van Goozen et al., 1998, 2000) and Pajer et al. (2006) who reported lower cortisol to DHEA ratio in CD girls but no differences in androstenedione or DHEAS. Adrenal androgens may be an important mechanism involved in the hormone–behavior relations as they are the first hormones to change during puberty (e.g., during adrenarche) and are precursors of more potent steroids, specifically, testosterone. In younger aged youth in the study, those hormones are likely to have just begun to increase. Further, adrenal androgen levels were related to externalizing behavior problems in healthy adolescents (Brooks-Gunn and Warren, 1989; Nottelmann et al., 1987; Susman et al., 1991; Udry and Talbert, 1988) but their role in ODD or CD is virtually unknown. Given the paucity of research, it is unclear whether gonadal and adrenal hormones are higher or lower in DBD youth, particularly at young ages.

Models examining the development of antisocial behavior or DBDs have been diverse and generally have examined unitary predictors without accounting for how these predictors are integrated with other key dimensions. To advance the literature regarding hormones and disruptive behavior disorder, a conceptual biopsychosocial model of the development of conduct problems has been articulated (Dodge et al., 2003). Their model included biological predisposition, sociocultural context, as well as parenting and peers as it relates to conduct disorder. Although this model cannot be tested in the cross-sectional analyses at hand, we used components of the model to consider associations between gonadal and adrenal hormones and disruptive behavior. Further we were guided by the notion that gonadal and adrenal hormones may be directly related to DBD but more complex theoretical models now are proposed that consider bidirectional relations moderated by contextual domains (Susman, 1997, 2006).

In line with the theoretical and empirical literature, we propose that children with ODD or CD will be different from the healthy comparison group on hormone levels but the relation of hormones and disruptive disorders will be moderated by contextual factors. Our selection of contextual factors (e.g., parent and family functioning as well as exposure to delinquent peers) was also based on an ecological perspective suggesting that interventions target these contextual factors to improve the behavior of children and youth (Kazdin, 2005; Kolko, 2002; Nock, 2003). Further, for both researchers and clinicians it is encouraged that risk factors be included in intervention studies so as to understand how the

broader social environment can improve the lives of children with DBD (Burke et al., 2002; Chronis et al., 2003). Therefore, we felt it was important to include these contextual domains in our model. The model led to the following aims and hypotheses. The first aim was to assess group differences in adrenal and gonadal hormones in youth with and without DBD. It was hypothesized that cortisol would be lower and T and adrenal androgens higher in those with DBD compared to the HC group. Gender differences also were examined in an exploratory fashion as fewer girls than boys were enrolled. Second, contextual factors previously associated with DBD (parental dysfunction, parenting practices, family conflict, exposure to delinquent peers) were examined as moderators of DBD and hormones. It was hypothesized that family disruption and exposure to delinquent peers in combination with disruptive behavior problems would be related to higher gonadal and adrenal hormone levels given the reported association between higher gonadal and adrenal hormones and aggressive behavior. No identified studies have examined hormones and DBD and the role that family/parenting environment and peer contexts may play in DBD. The study also controlled for potential confounds (e.g., medication, sampling time) and used multiple samples in a unique, randomized clinical trial (RCT) for treatment of DBD. Understanding potential hormone and context factors associated with DBD in developing youth may provide more insight into serious DBD in later adolescence.

## 2. Methods

### 2.1. Design

Children were recruited to a large, randomized clinical trial designed to treat DBD (Kolko et al., 2008). Participants were randomized to one of two specialized treatment protocols applied by research clinicians in either the community or outpatient clinic. An additional group was recruited to serve as a treatment-as-usual (TAU) group. Healthy comparison (HC) participants without DBD were matched to those in all three groups. Since no treatment had taken place at the baseline timepoint, the assignment to treatment groups is not relevant for this paper. This report includes only baseline information and thus groups are defined as DBD versus HC.

### 2.2. Participants

The study included 180 participants (141 boys, 39 girls), age 6–11 years ( $9.0 \pm 1.7$ ). The younger age was chosen to capture early experiences of DBD. Additionally this age represents the youngest likely able to participate in treatment in the clinical trial using cognitive behavioral therapy. Of the 180, there were 111 DBD and 69 HC participants (see Table 1). Inclusion criteria for DBD were: (1) boys or girls, age 6–11 years, (2) diagnosis of CD or ODD, (3) resided with one or more parent/guardian, (4) intellectual level no more than 2 SD below age norms, (5) parent/guardian consent, (6) not suicidal, psychotic and in no other treatment.

This (Kolko et al., 2008) sub-sample was drawn from of the larger parent study ( $N = 176$  DBD; 69 HC) and represents those with salivary hormone samples. The hormone sub-sample was funded at a later date than the parent study. DBD participants with saliva sampling were no different from the full sample of DBD participants on age, SES, or race. However, significant gender differences ( $p = 0.05$ ) indicated a higher proportion of girls in the current study (e.g., 21.7%) compared to the subgroup (10.8%) who did not participate in the saliva sub-sample. No differences were noted between participant/non-participant groups in externalizing behavior using the Child Behavior Checklist (Achenbach, 1991).

HC group eligibility criteria included: (1) matched on age ( $\pm 6$  months), gender, race, and SES ( $\pm 10$  points) (Hollingshead, 1975), (2) no acute or chronic illnesses, (3) no learning disabilities, (4) no current or past DSM-IV diagnoses, (5) resided with at least one parent/guardian, (6) intellectual level no more than two SDs below age norms, and (7) parental/guardian consent. The decision to use a HC group without psychopathology was reported to be useful in other studies of disordered versus non-disordered children and adolescents (Birmaher et al., 2004; Williamson et al., 2004).

### 2.3. Procedure

#### 2.3.1. Recruitment

For the special treatment groups, cases were referred from within and outside the participating institution. Two multiple-gate screening phases were used to determine the DBD sample. First, administration of the clinic screening form was used by phone or face-to-face interview to describe diagnosis, behavioral problems, and treatment needs. Second an assessment was conducted to determine general

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