

## Salivary testosterone and aggression, delinquency, and social dominance in a population-based longitudinal study of adolescent males

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### Abstract

Testosterone (T) has been found to have a stimulating effect on aggressive behavior in a wide range of vertebrate species. There is also some evidence of a positive relationship in humans, albeit less consistently. In the present study we investigated the relationship between T and aggression, dominance and delinquency over time, covering a period from early adolescence to adulthood. From a large population-based sample ( $n = 1.161$ ) a subgroup of 96 boys was selected whose behavior had been assessed repeatedly by different informants from age 12 to 21 years, and who had provided multiple T samples over these years of assessment. On the whole, a decrease in aggressive and delinquent behavior was observed in a period in which T rises dramatically. Boys who developed a criminal record, had higher T levels at age 16. In addition, positive associations were observed between T and proactive and reactive aggression and self-reported delinquent behavior. Over the pubertal years different forms of aggressive and delinquent behavior were positively related to T, which may indicate that specific positive links are dependent on the social setting in which this relationship is assessed.

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### Introduction

Testosterone (T), the most important male sex hormone, affects not only physical but also behavioral masculinization. For example, T has been found to increase aggressive behavior in a wide range of vertebrate species (Archer, 1988). Studies in male rodents show that competitive or intermale aggression increases at puberty, a time in which T levels dramatically rise. Also, administration of T results in an increase in aggression

(Brain, 1979), whereas it is reduced by (chemical) castration (see Van Goozen et al., 1995 for results in humans).

In human adults, T has been found to be related to delinquency, drug abuse (Dabbs and Morris, 1990) and criminal violence (Dabbs et al., 1995; Ehrenkranz et al., 1974; Kreuz and Rose, 1972; Strong and Dabbs, 2000), as well as to conduct problems in childhood (Dabbs and Morris, 1990). However, Bain et al. (1987) found no difference in T between men charged for aggressive or non-aggressive crimes. It is clear, therefore, that in humans the evidence is at best suggestive of a positive relationship (Archer, 1991).

Much less information exists about the relationship between T and aggressive behavior in children and adolescents. Some studies found a positive relationship between T and physical and

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verbal aggression (Olweus et al., 1980, 1988), persistent externalizing behavior (Maras et al., 2003), and age-graded norm-violating behaviors (Udry, 1990) in youngsters. Scerbo and Kolko (1994) studied pre- and early adolescent clinical cases and found that T was related to increased staff-rated aggression. Likewise, disruptive boys approaching puberty seem to have higher T levels as compared to normal controls (Chance et al., 2000). Sánchez-Martín et al. (2000) found a positive relation between T and the frequency of engaging in aggressive interactions in four-year-old boys. However, there are also quite a few studies that have found no relationship between aggression and T in youngsters (Constantino et al., 1993; Halpern et al., 1994; Inoff-Germain et al., 1988; Mattsson et al., 1980; Susman et al., 1987; Van Goozen et al., 1998). One study found a relationship between T and disruptive behavior in girls, but not in boys (Granger et al., 2003). In another study (Schaal et al., 1996) boys with a history of high levels of physical aggression between ages 6 and 12 had lower T levels at age 13 than boys without such a history.

These mixed findings in studies on children and adolescents may be due to important methodological differences between the studies. First, some studies used clinical samples of children referred for disruptive behavior disorders (Chance et al., 2000; Constantino et al., 1993; Scerbo and Kolko, 1994; Van Goozen et al., 1998), while others used population-based samples (Olweus et al., 1980; Schaal et al., 1996; Udry, 1990). Second, studies differ not only in sample size but also in the number of samples taken for T analysis. Third, different instruments have been used to investigate this relationship and therefore a mixture of information on various forms of aggressive or dominant behaviors (disruptive, assertive, or physically aggressive behaviors) has been collected (Tremblay et al., 1998). Studies that assess aggression have generally not taken into account different types of aggression, e.g., whether it is reactive or proactive in nature, and it could well be that different types of aggression have different relationships with T. Reactive and proactive aggression have been observed in children and adolescents (Brendgen et al., 2001; Dodge et al., 1997; Pulkkinen and Tremblay, 1992; Vitaro et al., 1998). And finally, studies examining the T-aggression relationship in youngsters obviously differed in the ages of their participants, ranging from prepubertal to postpubertal, which could clearly affect the results. Schaal et al. (1996) found that boys who were persistently physically aggressive had lower T levels at age 13 than boys who were physically aggressive, but these same boys had higher T at age 16, and therefore a group by time interaction was observed (Tremblay et al., 1997).

Studies in nonhuman primates also show a relatively strong association between testosterone and dominance (Mazur and Booth, 1998; Paikoff and Brooks-Gunn, 1990). Social dominance may or may not involve aggressive behavior and it has been suggested that a more direct relationship exists between T and dominance (Albert et al., 1993; Strong and Dabbs, 2000). This line of reasoning has been supported in humans (Schaal et al., 1996; Rowe et al., 2004; Archer, 2006), in which it was shown that testosterone levels were associated with social success rather than with physical aggression.

In the present study, we examined the relationship between testosterone, using multiple measurements of T in each year of assessment, and aggression, dominance, and delinquency, in a period covering early adolescence to adulthood. Puberty is a period in which T levels progressively rise from extremely low to mature levels, and it is also in most cultures a period of psychological development characterized by, among others, increases in antisocial and delinquent behavior (Moffitt, 1993; Weisfeld and Berger, 1983). One would therefore expect that a longitudinal study from late childhood to adolescence and adulthood could provide crucial data on the influence of T on aggression. To this end, we based our study partly on data reported by Schaal et al. (1996), but extended the measurement period to adulthood, and used a larger number of behavioral assessments. A first goal was to examine whether, in line with a rise in T, different types of aggressive, dominant, or delinquent behavior increased from early adolescence into adulthood. Secondly, we investigated whether physical aggression, social dominance and/or delinquent behavior, as shown from childhood to adulthood, had a positive relationship with (changing) T levels. We expected to find an overall increase in aggressive, dominant, and delinquent behavior, together with a rise in T, in our assessment period. Moreover, when examining T levels in separate years, we expected to find positive relationships between T and physical aggression, social dominance, and/or delinquent behavior.

## Materials and methods

### Participants

The participants involved in the present study ( $n = 96$ ) were part of a longitudinal study that started in 1984, when teachers of kindergarten classes in 53 schools in an urban area in Montreal were asked to rate the behavior of each boy in their classroom (Tremblay et al., 1994). Eighty-seven percent of the teachers agreed to participate, and 1,161 boys were rated. To minimize social and cultural effects, the boys were recruited according to the following criteria: (1) attending school in low socioeconomic areas of Montreal; (2) born from Caucasian, French-speaking parents themselves born in Canada; and (3) living with parents having medium to low educational status. The sample was reduced to 1,037 boys after applying these criteria and eliminating those who declined to participate and those who could not be located (Tremblay et al., 1991, 1994, 1995).

Physically aggressive behavior was assessed at ages 6, 10, 11, and 12 years by means of the fighting subscale of the teacher form of the French Canadian version of the Social Behavior Questionnaire (SBQ; Tremblay et al., 1991). Physical aggression could be determined for 893 boys, after boys who withdrew from the longitudinal project ( $n = 116$ ) and boys who had more than one missing value ( $n = 28$ ) had been eliminated (see also Séguin et al., 1995, 1996). Stable highly aggressive boys were defined as those who fell above the 70th percentile at age 6 and on two or more assessment points on the physical aggression scale (19% of the sample). Nonaggressive boys had scores that fell below the 70th percentile at all assessment points (35% of the sample). Those who did not meet the above criteria were classified as unstable aggressive boys (46% of sample). Compared to another sample of boys ( $n = 882$ ) representative of the whole province, physically aggressive behavior is over-represented in this urban community sample of low socioeconomic status (SES; Séguin et al., 1996).

For logistical reasons, we were able to invite approximately 200 13-year-old boys to come to the laboratory for various observational and experimental procedures. Several overlapping criteria were used to select this subsample. Exclusion criteria (for purposes not particular to this study) were applied as follows: 234 boys who could not be classified as stable anxious or stable

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