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Androgen levels and anger and impulsivity measures as predictors of physical, verbal and indirect aggression in boys and girls

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Summary Previous studies indicate that androgen levels and certain psychological characteristics such as anger and impulsivity are related to the development and maintenance of aggression. Further studies are required to analyze the potential predictor role of the interaction of said factors on aggressive behavior. 90 nine-year-old children (44 boys and 46 girls) were assessed in relation to their levels of physical, verbal and indirect aggression, using a peer-rating technique. Testosterone and androstenedione levels were analyzed using an enzymoimmunoassay technique in saliva samples. Anger (state and trait) and anger control were measured using the STAXI-NA, and impulsivity was measured through the MFF-20. A General Linear Model revealed that sex was the best predictor for aggression measures, with boys scoring higher than girls in physical, verbal and indirect aggression; after sex, testosterone was found to be the best predictor (in a positive sense) of all three types of aggressive behavior studied. In addition to observing a main effect of androstenedione on physical and verbal aggression, a 'state anger * - androstenedione' interaction was found to predict these types of aggression, with androstenedione acting as a moderator (inhibitor) of the effects of anger on these behaviors; also, a 'state anger * testosterone' interaction was found to predict verbal aggression. The results support the idea that, after sex, androgens constitute a biological marker to be taken into consideration in

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relation to individual differences in aggressive behavior. It is possible that at the age of 9, testosterone tends to increase aggression, while androstenedione tends to moderate (inhibit) the effects of anger on aggression.

1. Introduction

Although the study of the biological, psychological and social variables associated with aggressive behavior has resulted in a large amount of scientific literature, there can be no doubt that there is still much to learn about the processes underlying this behavior. Nevertheless, the majority of research has focused on these types of variables separately. One of the current approaches which, in our opinion, is most promising, is the biopsychosocial approach, which considers these variables together and which therefore offers a more integrating vision of aggressive behavior, its constituent elements and underlying mechanisms (Booth et al., 2003; Dodge and Pettit, 2003; Raine, 2002, 2005; Sánchez-Martín et al., 2009). One of the biological variables which has attracted most attention in relation to aggression is that of the endocrine correlates of aggressive behavior, with androgens being a key element for research in this sense (Archer, 2006; Moya et al., 2010). Most studies in this field have been conducted with pubescent youths and adults, which is why it seems important to study pre-pubescent populations in order to explore the developmental origins of aggression (Tremblay and Côté, 2005). Furthermore, some psychological characteristics with a high emotional or temperamental content, such as anger and impulsivity, have also been associated with aggressive behavior (Campbell, 2006; Vigil-Colet et al., 2008; Wittmann et al., 2008). As Deffenbacher et al. (1996) point out, constructs such as anger or aggression have often been used indiscriminately, when in fact both anger and impulsivity may be considered, at least in some cases, factors which facilitate aggressive behavior. It therefore seems important to take the aforementioned variables into consideration together, with the aim of assessing whether or not the interaction between biological variables (androgen levels) and psychological measures (anger and impulsivity) predicts aggressive behavior in subjects during a pre-pubescent development stage. The identification of psychobiological factors which influence the development of aggression may also be useful for professionals working in the field of treatment and prevention: if potential enhancing effects of different variables were to be discovered, then educational activities focusing on the management of psychological variables could help reduce the potential effect of biological variables, which are more difficult to influence by means of prevention activities.

In light of studies which will be discussed later, the biopsychosocial model we propose for our research contemplates a potential causal effect of androgens on aggression (hence their use as predictors in our model); this effect may be moderated by psychological characteristics such as anger and impulsivity, making the 'hormone levels * psychological characteristics' interaction relevant in the model underlying this piece of work.

Of the different types of aggression which can be established, the most appropriate distinction for the purposes of this study is between physical aggression (which implies direct physical action against another person, such as hitting, pushing, etc.), verbal aggression (which implies verbal action such as shouting in an intimidating manner, insulting, etc.) and indirect aggression (which implies relational actions such as spreading rumors about someone, ganging up on someone in order to isolate them socially, etc.). Analyzing the potential predictors of different types of aggressive behavior in early developmental stages will bring us one step closer to discovering the developmental origins of aggression.

In relation to the antecedents which link the aforementioned variables to aggressive behavior, there is currently a large body of evidence which links androgens to aggressive behavior, both in humans and in other species (Brain, 1977; Trainor et al., 2009). Research with animals has demonstrated that androgens may be a causal factor in the manifestation of aggressive behavior (De Ridder et al., 2000; Peters, 2002; Wingfield, 1984), although in humans, this causal nexus is much more difficult to establish. In fact, it is probable that, as in other species (Birger et al., 2003; Brain and Haug, 1992), in humans too there is a bidirectional relationship in which androgen levels may be both the cause and consequence of aggressive behavior. Although in humans the majority of studies carried out have focused on adults and post-pubescent youths, sufficient indication exists to suggest that androgens are also associated with the maintenance and development of aggressive behavior during the pre-pubescent phase, or at least constitute a biological marker or predictor of said behavior (Ramirez, 2003). Thus, in children, even though some authors have failed to find a relationship between testosterone and aggressive behavior (Constantino et al., 1993, with 4—10-year-old children; Van Goozen et al., 1998, with 8—12-year-old children), others have observed some kind of positive association between testosterone levels and aggression or externalizing behavior (Maras et al., 2003, with 14-year-old children; Sánchez-Martín et al., 2000, with 4-year-old children; Scerbo and Kolko, 1994, with 7—14-year-old children). In general, these studies have found a positive relationship between aggression and/or externalizing behavior and testosterone levels in boys, but not in girls. The studies which, in this area of research, have taken androstenedione into consideration have found a positive association between aggression or acting out behavior and androstenedione levels (Azurmendi et al., 2006 with 5-year-old children; Susman et al., 1987 with 9—14-year-old children; Van Goozen et al., 1998 with 8—12-year-old children), with this association being, in general, more consistent in boys than in girls.

Anger could be defined as an emotional state which includes feelings ranging from slight irritation to intense rage (Spielberger et al., 1983), and which usually occurs in response to a threat or deliberate and unjustified harm (Campbell, 2006; Kring, 2000). Although anger is not necessarily a prerequisite for some forms of instrumental aggression, in hostile or reactive aggression it is an emotional response frequently associated with provocation (Campbell, 2006). Some authors have published a preview of some results of a research project carried out over recent years, in which they found a small but significant correlation between anger and the hostile representation of aggression (Ramirez and Andreu, 2006). More recently, it was found that, in both preadolescents and adolescents (from 9 to 17 years of age), trait anger predicted physical and verbal aggression (the more anger, the more aggression) (Wittmann et al., 2008). The difference between state anger and trait anger (Deffenbacher et al., 1996; Spielberger, 1988) enables us to differentiate between a transitory emotional and physiological condition (state anger) and a stable personality dimension (trait anger). In our study, we will include both conditions along with anger control, in order to observe whether these dimensions have a different association with aggressive behavior or interact differently with androgen levels in their relation to aggressive behavior.

Little is known about the relationship between androgen levels and anger, although some studies have found a positive relationship between testosterone levels and anger levels (Herrero et al., 2010; Hohlagschwandtner et al., 2001; Van Honk et al., 1999). In a study with adolescents, Inoff-Germain et al. (1988) found positive relationships between diverse androgen levels (DHEA, DHEA-S, testosterone and androstenedione) and different measures of anger expression. In relation to this last variable, the authors found that, in girls, androstenedione was the only predictor of one of the expressions of anger assessed in the study, anger towards father, something which was not found in the case of 9—14-year-old boys.

Another factor that has been positively associated with aggression is impulsivity. Impulsivity can be defined as a predisposition to provide a rapid response to stimuli without properly assessing the consequences of said response (Gerbing et al., 1987; Moeller et al., 2001; Wittmann et al., 2008). Diverse studies have established an association between aggression measures and individual differences in impulsivity (Hynan and Grush, 1986; Luengo et al., 1994). In a recent study focusing on different age groups, it was found that impulsivity and aggression presented a consistent relationship pattern (Vigil-Colet et al., 2008), consisting of a positive association between impulsivity and the anger, physical aggression and verbal aggression measures used. The results indicated that impulsivity was specifically related to the emotional and instrumental aspects of aggression.

In relation to the potential relationship between androgens and impulsivity, the results of diverse studies suggest a positive relationship between the two variables. However, said studies reveal that the way in which the impulsivity variable is operationalized varies, making it difficult to identify a unifying or consistent pattern. Thus, Bjork et al. (2001) found a positive correlation between testosterone levels and errors made in a fast, adapted, decision-making test requiring selective attention and working memory. Other studies have found a relationship between venturousness and testosterone measures (Coccaro et al., 2007), as well as between impulsive aggression, characterized by violent unprovoked, non-premeditated attacks on strangers and testosterone levels (Virkkunen et al., 1994).

On the other hand, O'Connor et al. (2002), who took both testosterone and aggression and impulsivity levels into consideration in their study, failed to find any evidence that supraphysiological levels of testosterone lead to an increase in aggression or mood disturbances. More specifically, these authors found that the cognitive impulsivity trait (i.e. the tendency to make up one's mind quickly) and the motor impulsivity trait (i.e. the tendency to act on impulse) significantly explained part of the variance in aggression levels (over and above the level of testosterone); however, they did not assess the relationship between testosterone and impulsivity, both of which were considered as independent variables in the study. Consequently, it cannot be concluded that this study contradicts those cited previously. In addition to the relationship between testosterone and impulsivity, our study will also attempt to assess the potential moderator role played by impulsivity in the androgen-aggression relationship in pre-pubescent children.

In studies focusing on aggressive behavior, the sex variable is always important, since sex constitutes one of the best predictors of variance in said behavior (Archer, 2009). The existence of sex differences has been documented consistently in relation to physical aggression (in favor of males), verbal aggression (again in favor of males) and indirect aggression (in favor of females) (Archer, 2004; Baillargeon et al., 2007; Björkqvist, 1994; Lagerspetz et al., 1988). Taking the sex variable into consideration is also important because evidence exists that the relationship between hormones and aggression is different in girls and boys: the few studies conducted with both pre-pubescent boys and girls, focusing on the relationship between androgens and aggression, have found that this relationship is observed only in boys (Azurmendi et al., 2006; Sánchez-Martín et al., 2000).

Androgen levels undergo a number of changes during human development (Collaer and Hines, 1995; Cortés-Blanco et al., 2000; Forest, 1989). During childhood, up to the age of 7, androgen levels are lower than at any other stage of the life cycle. From the age of 7 until puberty, these levels gradually increase. In the case of testosterone, a 20—30-fold increase is observed in boys between the ages of 12 and 18. In the case of androstenedione, an increase occurs with menarche (around the age of 8) and then levels rise gradually to two or three times their original value during puberty.

Based on the background described above, the principal aim of this study is to explore the potential predictor role played by androgens, anger (state, trait and control), impulsivity and the interaction of these variables in (peer-rated) aggressive behavior (physical, verbal and indirect), taking the potential influence of sex on this relationship into consideration.

The relative stability of aggression throughout ontogeny, particularly as regards the most offensive levels (Broidy et al., 2003; Farrington et al., 2009; Huessmann et al., 2009), renders the consideration of predictor factors for aggression in early development stages particularly interesting. In this sense, regarding the importance of breaking down the components of aggressive behavior in order to understand the developmental origins of aggression, the study explores different types of this behavior with the aim of contributing to the analysis of the biological markers (potential predictors) associated with different types of aggression during pre-pubescence.

2. Methods

2.1. Participants

Participants were 90 nine-year-old Iberian children (44 boys and 46 girls) from eight classrooms in three state schools in Guipúzcoa and Cádiz (Spain). The socioeconomic status of subjects in the sample was considered as medium and medium-high, based on our knowledge of the area in which participants live. The children's parents were provided with detailed information about the study and all gave their written consent. Although the tests used during this study were not invasive and were all carried out in the school itself, the project was pre-approved by the ethics committee at the institution to which the authors belong. To select the sample, schools were chosen in the provinces in which the researchers' universities were located, with priority being given to schools with more than one class for the selected age group. The study was explained to the directors, teachers and parents, and their informed consent was requested. In the schools chosen to participate in the study, the maximum number of possible subjects was 137 for the age group in question (in accordance with the number of students enrolled in each centre for that particular academic year). The children's families were sent a letter containing the corresponding information and requesting their consent. Of all the families which received the letter, only 124 gave their informed consent. During the course of the study, the administration of the psychological tests and the collection of saliva samples, information regarding 34 subjects was lost due to their absence from class on the day the psychological tests were administered or the biological samples collected. Finally, data were obtained for all variables from 90 subjects.

2.2. Measuring aggression

Aggressive behavior was assessed using the Direct and Indirect Aggression Scale (DIAS) (Björkqvist and Österman, 1998), a peer-rating measurement instrument for aggressive behavior. The Spanish version of the scale published by the authors themselves in conjunction with the English one (Björkqvist and Österman, 1998) was used, although some items were modified slightly to facilitate their comprehension by children in this age group. The DIAS is a test containing 24 items in which each child is asked to rate each of their same-sex classmates on a Likert scale (0—4) for behaviors linked to physical aggression (7 items), verbal aggression (5 items) and indirect aggression (12 items). The final scores for each scale were obtained by adding together the scores for each item, and then dividing this total by the number of items which made up each scale. These three subscales were reliable for this sample: Cronbach's αs were .96, .89 and .83, respectively. A number of different research studies endorse this test as a suitable instrument for measuring the proposed aggression types in children, from a young age (Björkqvist et al., 2001; Valles and Knutson, 2008).

2.3. Measuring anger

Anger was measured using the State-Trait Anger Expression Inventory for Children and Adolescents (STAXI-NA) (Del Barrio et al., 2005), TEA Ediciones, Spain. This test (self-report), which consists of 32 items, assesses different behaviors (experience, expression and control) and facets (state and trait) of anger. For this study, the state anger, trait anger and anger control measures were used. State anger is an angry, one-off reaction to a specific event at a specific moment, while trait anger is a tendency to manifest intense angry reactions more frequently. Finally, anger control is the capacity both to give feelings of anger a controlled outlet, and to control them by calming down and/or relaxing (Del Barrio et al., 2005). The internal consistency for these scales was .81 for state-anger, .71 for trait-anger and .74 for anger-control. Even though a peer-rating test was used to measure aggression, we consider a self-report test to be more appropriate for assessing anger, since firstly, the aim is to measure a more internal characteristic, which the subject is in the best position to assess, and secondly, it provides an independent measurement for both variables and avoids possible contamination, since the information comes from different sources for each variable.

2.4. Measuring impulsivity

Impulsivity was measured using the 20-question Matching Familiar Figure Test (MFF-20) [Spanish adaptation by Buela-Casal et al., 2002, TEA, of the test by Cairns and Cammock (1978)]. The MFF-20 is a perceptive matching test which generally takes between 15 and 20 min to administer, in an individual interview, and in which impulsivity (many errors, short time) and inefficiency (many errors, long time) measures are obtained based on errors committed and response latency. It is a test which contains twelve items in which the subject is presented with a familiar drawing which he or she has to match to its exact copy. Six possible answers are provided, of which only one is an exact copy of the original. A timer is used to measure how long the subject takes to give their first answer, and if they choose incorrectly, they are given another chance to find the exact copy, with a record being kept of the number of mistakes made (Buela-Casal et al., 2002). From these direct scores, the typical normalized scores are obtained. Both subscales had high internal consistency (αs were .94 for latency and .75 for errors). In this study, only those impulsivity measures obtained by subtracting the typical latency scores from the typical error scores were used (impulsive subjects are characterized by a low response latency and a high number of errors). This test assesses cognitive style in the Reflexivity—Impulsivity polarity, in which Reflexivity implies a tendency to think before answering, and Impulsivity implies a tendency to answer without thinking first.

2.5. Determining androgen levels in saliva

Two saliva samples were collected from each subject, one at the beginning and the other at the end of a six-week interval in order to obtain a baseline for androgen levels. All samples were collected at the same time: from 0900 h to 0915 h. Subjects were asked to deposit their saliva in a biological sample collection pot; to facilitate salivation, each child was given a sweet and told they could only eat it once enough saliva had been collected. Upon arrival at the laboratory, each subject's sample was stored in two different tubes (one for testosterone and the other for androstenedione). The samples were frozen and stored in the laboratory at −80 °C until subsequent analysis using an ELISA technique (Salimetrics, State College, USA), with each sample being analyzed in duplicate. For testosterone, the average intra-assay coefficient of variation (CV) was 6.7%, and the average inter-assay CV was 14.05%. For androstenedione, the intra and inter-assay CVs were 7.5% and 8.5%, respectively.

The two values for each hormone were averaged, since they were correlated, bearing in mind the duplicates of the two samples (testosterone: $r = 0.571$, $p = .0001$, for boys $r = 0.700$, $p = .0001$ and for girls $r = 0.502$, $p = .0001$; androstenedione; $r = 0.704$, $p = .0001$, for boys $r = 0.697$, $p = .0001$ and for girls $r = 0.683$, $p = .0001$), with the result being a single score for each hormone and for each subject.

2.6. Statistical analysis

All the variables were transformed into Z scores in order to cancel the effect of the range disparity problems (physical aggression: 0–2.47; verbal aggression: 0–2.70; indirect aggression: 0–2.25; state anger: 8–17; trait anger: 8–24; anger control: 8–24; impulsivity: −6.15 to 2.99). Since they did not have a normal distribution, physical aggression, verbal aggression and indirect aggression were normalized using the square root transformation, and the hormone measures were normalized using the log+1 transformation. Given the particular distribution of some of the psychological variables, particularly state anger and trait anger (positively skewed), and in accordance with the chosen analysis strategy, these variables were dichotomized for the said analyses into high and low levels, with the dividing line between the two being established in the median. For all analyses, we adopted a conservative threshold of $p < .02$ for statistical significance.

In order to analyze sex differences in relation to the different variables analyzed in the study, a one-way ANOVA was conducted. The relations between the different variables considered in the study were examined using a Pearson correlation coefficient.

In order to analyze the potential predictor role of sex, hormone levels, psychological variables and their interactions, a General Linear Model (GLM) was performed, taking the different types of aggressive behavior (physical, verbal and indirect) as dependent variables. To assess the significant interactions, we followed the regression approach outlined in Baron and Kenny (1986) and in Frazier et al. (2004).

3. Results

3.1. Sex differences

Our findings show that boys scored higher in physical ($F = 45.31$; $p = .0001$), verbal ($F = 22.49$; $p = .0001$) and indirect ($F = 19.81$; $p = .0001$) aggression ratings than girls. However, androstenedione levels were higher in girls than in boys ($F = 7.51$; $p = .007$). No significant sex differences were found for the other variables ($p < .02$) (Table 1 for the descriptive statistics).

Table 1 Sex differences, means and standard deviations of all variables.

	Mean	SD	F
Physical aggression			
Boys	.9381	.58683	33.382**
Girls	.3810	.28275	
Verbal aggression			
Boys	1.0299	.56092	20.189**
Girls	.5823	.36832	
Indirect aggression			
Boys	.8570	.45044	17.660**
Girls	.5144	.31363	
Impulsivity			
Boys	−.9136	1.84757	.007
Girls	−.8837	1.58933	
State anger			
Boys	8.6591	1.64166	.276
Girls	8.8696	2.11459	
Trait anger			
Boys	11.2727	2.45294	.138
Girls	11.5000	3.26428	
Anger control			
Boys	16.2500	3.65440	5.011
Girls	17.9565	3.57744	
Androstenedione			
Boys	51.9323	31.65440	8.710**
Girls	75.4270	42.77644	
Testosterone			
Boys	23.2314	10.08026	.601
Girls	24.7746	8.78713	

** <.01.

3.2. Correlational analysis

Pearson correlations were performed to explore the relationships between each predictor and the dependent variables in boys and girls (Table 2). No significant relationships were found between the predictor and dependent variables in boys or girls. The different types of aggression (physical, verbal and indirect) were closely inter-correlated. A positive correlation was also observed between testosterone and androstenedione measures. State anger correlated positively with trait anger in boys, and anger control correlated positively with testosterone in boys.

3.3. Predictor role of sex, hormone levels, psychological variables and their interaction in aggression

A General Linear Model (GLM) was performed for each of the three types of aggression, with sex, hormones, psychological variables and the 'psychological variables * hormones', 'hormones * sex' and 'psychological variables * sex' interactions being introduced as predictors in an initial model. Since in this model, none of the interactions with sex were found to be significant for any of the three aggression types (physical, verbal or indirect), a second model was established in which interactions with sex were not included. The models obtained for physical aggression ($R^2 = .38$; $\chi^2 = 44.77$; $p = .0001$), verbal aggression ($R^2 = .31$; $\chi^2 = 35.65$; $p = .002$), and indirect aggression ($R^2 = .27$; $\chi^2 = 31.55$; $p = .007$) were all significant.

As shown in Table 3, a statistically significant main effect of sex, androstenedione and testosterone was observed for

Table 2 Correlations between androgens, anger (state, trait and control), impulsivity and aggression (physical, verbal and indirect) for boys (top of the table) and girls (bottom of the table).

	1	2	3	4	5	6	7	8	9
1. Physical aggression	–	.945**	.899**	.162	.160	.285	−.021	−.019	.123
2. Verbal aggression	.865**	–	.923**	.217	.278	.344	.066	.029	.143
3. Indirect aggresion	.794**	.921**	–	.121	.113	.290	.049	.048	.183
4. Impulsivity	−.119	−.054	−.028	–	.197	.170	.016	.057	−.030
5. State anger	.137	.173	.255	−.127	–	.353**	−.059	−.084	−.135
6. Trait anger	.071	.190	.197	.014	.164	–	−.021	−.138	−.190
7. Anger control	−.252	−.070	−.051	−.227	−.086	.086	–	.335	.426**
8. Androstenedione	−.174	−.195	−.184	.134	−.262	.136	.184	–	.682**
9 Testosterone	−.118	−.108	−.081	.122	−.278	.085	.262	.866**	–

** $p < .01$.

Table 3 GLM for physical, verbal and indirect aggression.

	Physical aggression		Verbal aggression		Indirect aggression	
Source	X^2	P	X^2	P	X^2	P
Sex	26.528	<.0001***	16.312	<.0001***	13.586	.0002***
Impulsivity	.190	.662	.027	.868	.821	.364
State anger	1.283	.257	2.890	.089	1.677	.195
Trait anger	.089	.765	.491	.483	1.162	.281
Anger control	1.792	.180	.421	.516	.437	.508
Androstenedione	5.583	.018**	6.430	.011**	4.332	.037*
Testosterone	4.803	.028*	5.815	.015**	5.188	.022*
Impulsivity * Androstenedione	.232	.629	1.473	.224	.358	.549
Impulsivity * Testoterone	.955	.328	2.737	.098	1.432	.231
State Anger * Androstenedione	5.423	.019**	7.097	.007**	2.211	.137
State Anger * Testosterone	2.892	.089	5.224	.022*	1.814	.177
Trait Anger * Androstenedione	3.011	.082	3.216	.072	.695	.404
Trait Anger * Testosterone	1.923	.165	1.920	.165	.203	.652
Anger Control * Androstenedione	2.307	.128	3.435	.063	2.757	.096
Anger Control * Testoterone	.680	.409	1.699	.192	1.928	.164

* $p < .02$.
** $p < .01$.
*** $p < .001$.

physical aggression, as well as a statistically significant effect of the 'stage anger * androstenedione' interaction. To analyze this interaction, simple regression analyses were conducted for the two state anger levels (low and high), using androstenedione as the predictor and physical aggression as the dependent variable. Although these regression analyses failed to reveal any significant results, the slope for high state anger was sharper (−0.35) than for low state anger (−0.19), thus indicating that in the case of high state anger, the more androstenedione, the less physical aggression (Fig. 1).

For verbal aggression (Table 3), a statistically significant main effect of sex, androstenedione and testosterone was observed, as well as a statistically significant effect of the 'state anger * androstenedione' interaction and the 'state anger * testosterone' interaction. To analyze the 'state anger * androstenedione' interaction, simple regression analyses were conducted for the two state anger levels (low and high), using androstenedione as the predictor and verbal aggression as the dependent variable. Although these regression analyses failed to reveal any significant results, the slope for high state anger was sharper (−0.31) than for low state anger (−0.15), thus indicating that in the case of high state anger, the more androstenedione, the less verbal aggression (Fig. 2).

To analyze the 'state anger * testosterone' interaction, simple regression analyses were conducted for the two state anger levels (low and high), using testosterone as the predictor and verbal aggression as the dependent variable. These regression analyses failed to reveal any significant results and the slopes (−0.01 for high anger and 0.02 for low anger) shown in Fig. 3 do not show any explicit tendency for the interaction 'state anger * testosterone'.

For indirect aggression (Table 3), a statistically significant main effect of sex and testosterone was observed.

4. Discussion

Firstly, sex constituted the best predictor for all three types of aggression studied, physical, verbal and indirect, with boys scoring higher than girls in all three types. In relation to

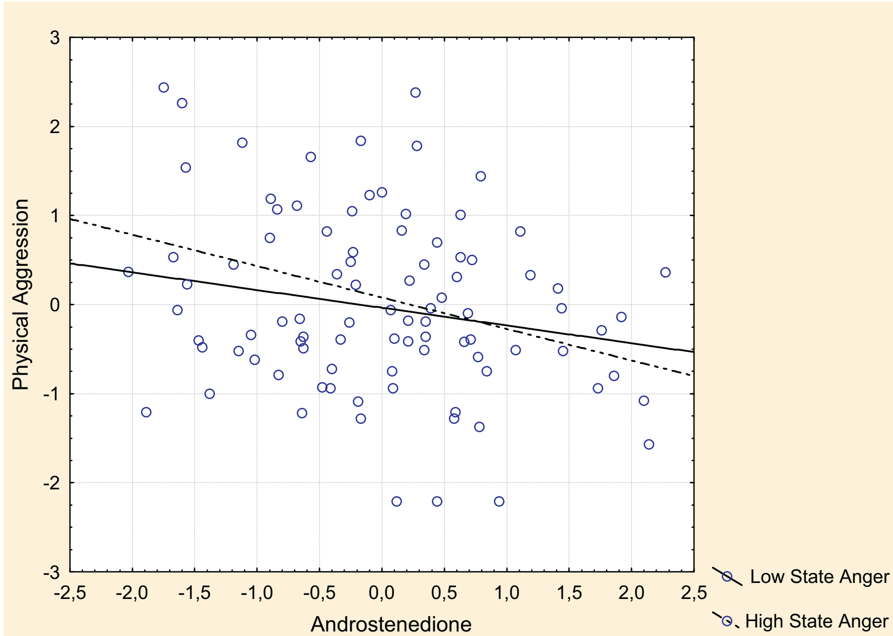

Figure 1 Interaction between androstenedione and state anger in physical aggression.

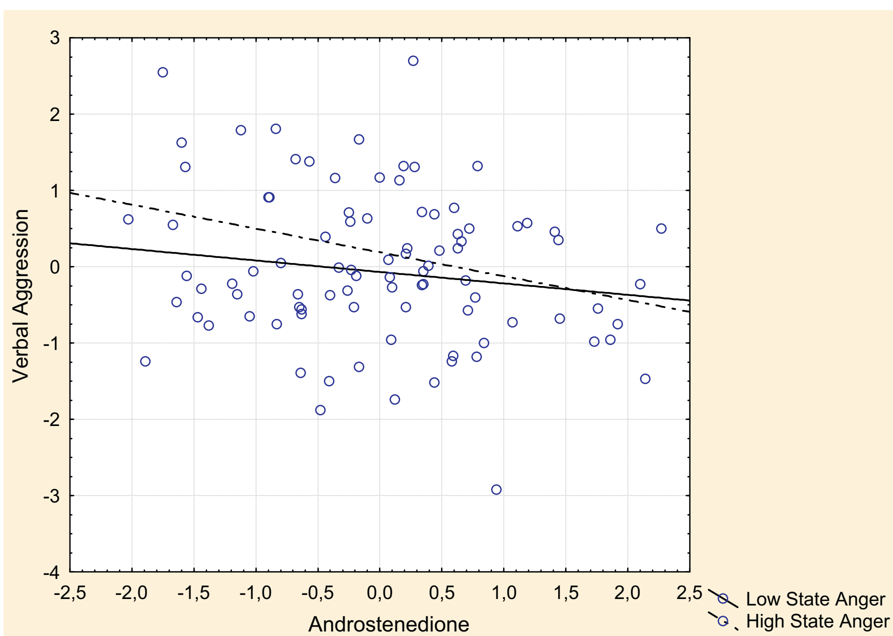

Figure 2 Interaction between androstenedione and state anger in verbal aggression.

physical and verbal aggression, our results are consistent with those presented by numerous other studies which found that from a very early age, boys display higher levels of physical and verbal aggression than girls (Archer and Côté, 2005; Baillargeon et al., 2007). With regard to indirect aggression, diverse studies have found that girls engage in this behavior more often than boys, although the most consistent result is that girls use this type of behavior more than the other two forms of aggression (Björkqvist et al., 1992b; Craig et al., 2002; Vaillancourt, 2005). Our results, however, indicate that in our study, boys had higher indirect aggression measures than girls. In accordance with this result, a number of other studies have also found sex differences in favor of males in this type of aggression (David and Kistner, 2000; Hennington et al., 1998; Tomada and Schneider, 1997). Björkqvist et al. (1992a) suggested that sex differences in favor of girls with regard to indirect aggression are not clearly distinguishable until the age of 11, a difference that is related to increased social intelligence in girls at this age.

It is worth highlighting the fact that, when considering the predictor role of biological (androgens) and psychological (impulsivity, anger and anger control) variables and their

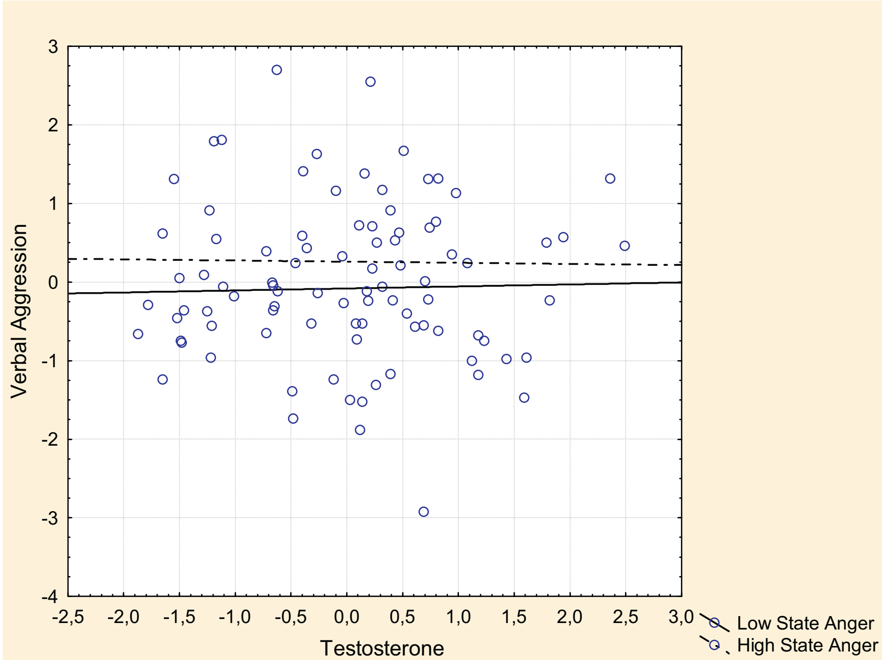

Figure 3 Interaction between testosterone and state anger in verbal aggression.

interactions in aggressive behavior, testosterone and androstenedione were found to be the best predictors. The fact that testosterone constitutes a (positive) predictor of different types of aggression is worth noting, and is consistent with the findings of previous studies in this respect, both in pre-pubescent (Sánchez-Martín et al., 2000; Scerbo and Kolko, 1994), pubescent (Olweus et al., 1988; Yu and Shi, 2009) and post-pubescent subjects (Dabbs et al., 1987; Ehrenkranz et al., 1974), although it is also true that some studies have failed to find any association of this kind (Bain et al., 1987; Constantino et al., 1993; Susman et al., 1987). Our results support the idea that testosterone may be a biological marker for aggression in pre-pubescent ontogenetic development stages. Moreover, it is also interesting to note that testosterone constitutes a predictor for all three types of aggression, physical, verbal and indirect, a finding which lends added relevance to this conclusion.

Androstenedione was found to be negatively associated with physical and verbal aggression, and an effect of the 'state anger * androstenedione' interaction was observed for both these aggression types. The analysis of the slopes of the interaction may indicate a tendency for androstenedione to reduce the potential enhancing role of anger on aggression. When we take into consideration the results of other studies regarding the androstenedione-aggression relationship, we see that mainly, a positive association has been established between androstenedione levels and measures of aggression or related behaviors in boys. Thus, in a study of 5-year-old children, Azurmendi et al. (2006) found that androstenedione was a predictor of a moderate form of aggression, provocation, only in boys. Sánchez-Martín et al. (2009) found that in 5—6-year-old boys (but not girls) with high androstenedione levels, directive maternal behavior was associated with greater physical aggression. Van Goozen et al. (1998) found a positive, marginally significant relationship between androstenedione and behavioral disorders in 8—12-year-old boys. On the other hand, some studies have found associations in girls between androstenedione measures and behaviors such as the expression of anger or competitive feelings. Thus, in a study of 9—14-year-old girls, Inoff-Germain et al. (1988) found that androstenedione was a predictor of expression of anger towards father, and of attempts to control parents' behavior. For her part, while studying 19—26-year-old women, Cashdan (2003) found that high levels of androstenedione were associated with a greater likelihood of expressing competitive sentiments through verbal aggression. We see then, that with the exception of Cashdan's study (2003), which was conducted with women in a post-pubescent development stage, none of the works cited above actually establish a relationship between androstenedione and aggression itself, in girls. In this present study, we failed to find any effect of the interaction between androstenedione measures and sex on aggressive behaviors, and the correlations between this hormone and aggression failed to reach significance level for either of the two sexes. Nevertheless, it is striking that the correlations between hormones and aggression were always negative for girls and almost always positive for boys. This leads us to suspect that with a larger sample group, we might have observed a different relationship between androstenedione and aggression in girls and boys. We could speculate on the possibility that, at this age, androstenedione plays an inhibitor role on physical and verbal aggression, or, in light of our results, on the anger levels that may trigger physical and verbal aggression, and that this role is more accentuated in the case of girls. This may facilitate, in this development stage, the use of less risky aggressive strategies in contexts of conflict, such as indirect aggression, for example, which has been related to developmental advantages for women (Campbell, 1999). However, our argument regarding the role of androstenedione is speculative, and requires further empirical research. Nevertheless, it is striking that despite the existence of a close positive correlation between testosterone and androstenedione, the two hormones have an opposite relationship with aggression measures. The fact that some subjects in our sample, particularly girls, may have been close to puberty at the time the study was conducted may have influenced the results obtained (in fact, girls were found to have higher androstenedione levels than boys). However, not having taken subjects' pubescent development stage into consideration, we are unable to assess this possibility.

In addition to the aforementioned effect of the 'state anger * androstenedione' interaction, an effect of the 'state anger * testosterone' interaction was also observed on verbal aggression, but the analysis of the slopes of this interaction do not show any explicit tendency for the interaction. The limits in relation to statistical power imposed by the sample size when analyzing interactions, prevents us from clearly determining the effects of this interaction.

Neither impulsivity itself nor its interactions with hormone measures were found to have any predictor role for aggression. Some authors have pointed out that it is dysfunctional impulsivity (Dickman, 1990), characterized by the taking of fast, non-reflective decisions which have negative consequences for the subject, that is associated with aggressive behavior (Vigil-Colet et al., 2008). The test used in this study does not specifically measure this type of impulsivity, and perhaps reflects an attentional bias which partially overlaps the impulsivity trait (at present we know of no psychometric test for children in the age group studied here which assesses dysfunctional impulsivity). Perhaps this was a handicap in the assessment of the relationship between impulsivity and aggression in our study.

We can conclude by stating that, in our study sample, sex constitutes the best predictor for aggressive behavior, with boys showing more physical, verbal and indirect aggression than girls. The second best predictor was hormone measures, with testosterone being a positive predictor of all three types of aggression; the 'state anger * testosterone' interaction also had an effect on verbal aggression. In the case of androstenedione, in addition to the main effect of this hormone on physical and verbal aggression, the 'state anger * androstenedione' interaction was also found to predict these two types of aggression. Thus, a moderator (inhibitor) effect of androstenedione was found, in the sense that, in subjects with high state anger, the more androstenedione, the less physical and verbal aggression. The psychological variables studied were not found to predict any of the three types of aggression.

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Conflict of interest

The authors report no conflict of interest.

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