Examining the effect of prenatal testosterone and aggression on sporting choice and sporting longevity.

Abstract

Digit ratio (2D:4D; a putative correlate of prenatal testosterone) has been reported to be negatively associated with aggression in non-sporting and sporting populations. 2D:4D has previously been suggested to be a potential biomarker for successful competitive performance within boxing football, rugby, athletics, skiing, and gym-based exercises. However, to date no study has attempted to investigate prenatal testosterone levels as a predictor of sporting choice. This study included a sample of both athletes and non-sports people in order to examine associations between prenatal testosterone (2D:4D), aggression, choice of sport (contact vs. non-contact), attainment level, and longevity. 200 male participants completed a self-report measure for aggression followed by providing a hand scan, which was later used to measure 2D:4D using Vernier Callipers. Results showed individuals involved in sport exhibited significantly greater levels of both prenatal testosterone (lower 2D:4D) and physical aggression compared with their non-sporting counterparts. Athletes from contact sports (rugby, football and boxing) were found to have significantly lower 2D:4D and significantly higher levels of physical aggression compared to athletes from non-contact sports (basketball, golf, weight-training, badminton). Additional findings, regarding longevity, showed those exposed to higher levels of prenatal testosterone (low 2D:4D) had been involved in sport for more years compared to those with high 2D:4D, adjusting for age. Findings may contribute to more reliable predictions of sporting selection and longevity. Future studies should look to replicate findings across a greater variety of sports using professional/elite populations.

Key words: Digit ratio, aggression, sporting choice, sporting longevity.

Introduction

There is evidence to suggest that the relative lengths of the second and fourth fingers (2D:4D ratio) correlate negatively with prenatal testosterone (Manning, 2011; Manning et al, 1998; Zheng & Cohn, 2011). There are a considerable number of papers concerned with uncovering links between 2D:4D and aggression (Hönekopp & Watson, 2011). The evidence points to a weak negative correlation between 2D:4D in men, with little in the way of significant associations being found in women (Hönekopp & Watson, 2011). However there are now a growing number of studies showing negative relationships between 2D:4D and 'real-world' measures of aggression, including aggression in non-sporting contexts (Schwerdtfeger, Heims & Heer, 2010; Joyce et al., 2013) and during sporting contests (Kilduff et al, 2013; Perciavalle et al., 2013; Bennett et al., 2010; Mailhos et al, 2016). Individuals involved in sport have been shown to exhibit significantly higher levels of aggression (Sønderlund et al., 2014), with aggression being recognised as a potential prerequisite to sporting success, in male-to-male physical competition (Perciavalle et al., 2013; Tamiya, Lee & Ohtake., 2012). General aggression has been defined as behaviour intended to harm another individual (Archer, 2009). However, in the context of sport, aggression typically refers to a tendency to force actions (Kerr, 2004), directly resulting in the experience of either positive (e.g. a successful tackle or punch) or negative (e.g. a red card or sanction for dangerous behaviour) outcomes. Research has demonstrated a relationship between prenatal (equivocal findings), and circulating, testosterone and levels of psychological and behavioural aggression (Perciavalle et al., 2013; Hönekopp, 2011). Testosterone therefore has been widely acknowledged as a key contributor to higher levels of aggression among males compared to their female counterparts across a variety of cultural, social and ethnic groups (Hönekopp & Watson, 2011). Hönekopp (2011) has suggested that prenatal testosterone has a permanent masculinising effect on human functioning and behaviour. The 2D:4D ratio (relative difference in length between the index and ring fingers) is a putative marker for prenatal testosterone, whereby higher testosterone levels correspond with a relatively longer fourth finger or lower 2D:4D (Manning, 2002; Hönekopp, 2011). 2D:4D is now commonly used as a proxy measure of individual differences in prenatal testosterone exposure due to ease of procurement and reproducibility (Perciavalle et al., 2013).

Prenatal testosterone (2D:4D) has been shown to be negatively associated with a behavioural measure of aggression, i.e., traffic violations, in males (Schwerdtfeger, Heims & Heer, 2010). Moreover, in a study that included a relatively large sample (N = 2200), 2D:4D was negatively associated with verbal and physical aggression in males (Hönekopp, 2011). Elsewhere, Perciavalle et al. (2013) showed that professional soccer players who had been exposed to higher levels of prenatal testosterone were more likely to have committed more playing fouls that resulted in yellow or red cards over the course of a season. The same authors also reported both aggression and prenatal testosterone levels to be significantly greater within the soccer players compared to controls, mirroring the findings of Bennett et al. (2010) within a sample of elite rugby players. Furthermore, Mehịbe et al. (2009) found that secondary school students who were regularly participating in sporting activities recorded significantly higher scores for destructive aggression compared to their non-sporting counterparts. More recently, Mailhos et al. (2015) showed within a sample of junior Uruguayan soccer players the most aggressive (i.e. those awarded one or more red cards) possessed a lower 2D:4D ratio compared to their less-aggressive counterparts.

2D:4D has previously been suggested to be a potential biomarker for successful competitive performance in several sports including skiing (Manning, 2002), and gym-based exercises (Hönekopp, Manning & Muller, 2006). More recently, 2D:4D studies demonstrated significant associations between greater levels of prenatal testosterone and performance within the sports of athletics (e.g. middle- and long-distance running) (Hönekopp & Schuster, 2010), rugby (Bennett et al., 2010), and football (Perciavalle et al., 2013). Bennett et al. (2010) found that among elite rugby players, the number of tries scored and number of international appearances were both significantly higher in those with lower 2D:4D ratios, after adjusting for playing position and age respectively. Interestingly, low 2D:4D may also be a predictor of success and longevity, with support for this notion found within a group of financial traders (Coates et al., 2009). Longevity is a particularly important phenomenon to understand in sport where careers are usually short-lived as a result of physical and or psychological burnout (Burgess, Naughton & Hopkins, 2012).

However, despite previously reported links between 2D:4D and aggression within studies investigating sporting success (Perciavalle et al., 2013; Tamiya, Lee & Ohtake., 2012), high levels of prenatal testosterone are not unequivocally synonymous with high rates of reported aggression or aggressive behaviours (Perciavalle et al., 2013). For example, Perciavalle et al. (2013) did not provide evidence of a significant correlation between extraggression and 2D:4D and many of the subscales of their aggression measure demonstrated poor internal consistency. Golby and Meggs (2011) contradicted many of the previous findings by demonstrating that athletes with the lowest 2D:4D ratios, who also competed at the highest levels of sport, self-reported some of the lowest levels of hostility (one of four commonly used sub-scale measures of aggression [Webster et al., 2014]). Therefore, it is evident that further exploration into the association between aggression, sporting success and prenatal testosterone exposure is needed.

Despite previous research (Tomar and Singh, 2012; Golby & Meggs, 2011) using heterogeneous sport samples, these studies failed to report on analysis of differences in psychological characteristics and 2D:4D among athletes competing in different sports (Perciavalle et al., 2013; Joyce et al., 2013). The extant literature has predominantly focused on the association between prenatal testosterone and psychological, physiological and behavioural variables important in sport performance (Bennett et al., 2013; Golby & Meggs, 2011). To the authors' knowledge, no study has attempted to investigate prenatal testosterone levels as a predictor of sporting choice among males. This exploratory study was therefore primarily designed to explore the relationship between 2D:4D and levels of aggression, investigating for inherent differences between sporting groups in order to uncover potential inferences regarding the effect of prenatal testosterone on sporting choice. Specifically, this study focused on the ability of 2D:4D to distinguish between athletes in explicitly aggressive (contact) and non-aggressive (non-contact) sports. It was anticipated that those athletes with low 2D:4D would have selected contact sports over non-contact sports. This hypothesis was partly based on the recent findings of Ribeiro et al (2016) whom reported increases in levels of testosterone as a response to an aggressive challenge, such as an encounter during a contact sport. This was found to be most significant within low 2D:4D individuals, whom appeared to respond to such a challenge by producing a marked spike in testosterone resulting in an increase in both aggression and strength (Ribeiro et al., 2016). This correlates with the work of Joyce et al (2013) who found those individuals presenting themselves with a 'boxer's fracture' due to an aggressive-related injury had a statistically significant smaller 2D:4D ratio in comparison to the normal population mean ratio. Additionally, this study looked to investigate prenatal testosterone's potential contributory effect on longevity; it was expected that individuals with the most year's involvement in their sport would report the lowest levels of 2D:4D, thus mirroring the findings of Coates et al. (2009) within their sample of financial traders.

Methods

Participants

The participants in this study were a sample of 200 male collegiate and university students aged 16-30 years (M_{age} = 20.13; S.D.: 4.4). 175 participants represented an even split across the following groups: badminton, basketball, golf, weight-training (non-contact sports [n = 100]), boxing, football, and rugby (contact sports [n = 75]), from all levels of sporting achievement: International/national (n = 12), Regional (n = 110), Recreational (n = 53). A further 25 participants represented a non-sporting group.

Measures

Aggression

The 12-item Brief Aggression Questionnaire (BAQ) (Webster et al., 2014) provides an overall value of aggression across four sub-scale measures: Physical aggression, Verbal aggression, Anger, and Hostility. Statements are rated on a five point Likert scale, ranging from '1= extremely uncharacteristic of me' to '5 = extremely characteristic of me'. Webster et al. (2014) showed the BAQ to have strong test-retest reliability and to replicate the Buss-Perry scale; which has acceptable psychometric properties (Buss & Perry, 1992). The measure has previously been shown to demonstrate reliability among contact athletes, non-contact athletes, and non-athletes (Lemieux, McKelvie & Stout, 2002).

Digit ratio measurement

A portable, digital hand scanner was used to take a copy of participants' right hands. Digit ratio was measured using Vernier Calipers (Fink, Thanzami, Seyde & Manning, 2006) accurate to 0.01mm. Kim, Kim and Kim (2014) reported that the right hand tends to exhibit more robust gender differences, displaying greater sensitivity to prenatal androgens when compared with the left. Digit length was determined by the distance between the metacarpo-phalangeal crease to the fingertip (Bennett et al., 2010), measured by two independent researchers (intra-correlations were 0.99). Digit ratio was calculated by dividing the length of the 2^{nd} digit (index finger) by that of the 4^{th} (Manning and Hill, 2009). Participants who had disclosed previous breaks or dislocations to either digit were excluded from the study due to potential distortions in finger length (Joyce et al., 2013).

Procedure

Following approval from Sheffield Hallam University's Ethics Committee, informed consent was procured from each participant prior to testing, explaining the confidentiality and anonymity of results. Additional parental consent was obtained for those under the age of 18. Via a brief questionnaire participants were first asked to provide information pertaining to their age, education level and previous finger injuries. Participants were then asked to place themselves within one of eight groups. If participants selected one of the seven sporting groups they were subsequently asked to provide information regarding the number of years of involvement and their highest level of achievement within this sport. Participants completed the aggression questionnaire then provided a digital scan of their right hand, which was printed out at a later date to be measured. Participants were informed that no finger prints would be identifiable from the hand scans (Perciavalle et al., 2013) and any electronic or paper copies would be immediately and appropriately disposed of once the data had been captured.

Data analysis

All data was calculated and analysed using IBM SPSS Statistics version 22. The data satisfied all collinearity and normality assumptions prior to analysis. Pearson's correlation co-efficient, including additional partial correlations, was used to assess the nature of the relationships between all measured variables. An independent samples t-test was conducted to assess differences in mean 2D:4D scores between contact and non-contact sports. Differences in 2D:4D means across all sporting groups was assessed via a one-way ANOVA, with post hoc analysis using the Tukey test to show differences significant at the 0.05 level.

Results

Table 1: Correlation matrix

	2D:4D	Years in competitive sport	Physical aggression	Verbal aggression	Anger	Hostility	Sporting attainment	Sporting choice
2D:4D		-.195** (-.163*)	-.231** (-.189**)	-.144* (-.122*)	-.119 (-.019)	-.012 (-.008).	-.071. (-.064)	.200** (.157)
Years in competitive sport			-.274** -.119.	-.11 .076.	-.27** -.117*	-.234** -.126.	.478** .358*	-.056. -.042
Physical aggression				.414** .312*	.574** .448*	.342** .123*	-.025. -.028	-.001. -.001.
Verbal aggression					.458** .324**	.293** .213*	-.053. -.048	.151* .142*
Anger						.474** .345**	-.0751. -.0654.	-.0341. -.0289.
Hostility							-.141. -.132.	.021. .018

N.B.: * p<0.05, ** p <0.01.

A correlation matrix showing relationships (zero order product-moment correlations) between 2D:4D and seven variables. Partial correlation coefficients are also shown in brackets.

badminton, basketball, golf, weight-training (non-contact sports [n = 100]), boxing, football, and rugby

Table 2: Mean 2D:4D for contact and non-contact sport athletes

No sport 2D:4D (Mean/S.D.)	Badminton 2D:4D (Mean/S.D.)	Basketball 2D:4D (Mean/S.D.)	Golf	Weight-training	Boxing	Football	Rugby
0.9669 (.032)	.9720 (.033)	.95 (.024)	.9531 (.034)	.9473 (.036)	.9346 (.028)	.9521 (.025)	.9385 (.028)

2D:4D ratio was negatively and significantly related to years in competitive sport, physical aggression and verbal aggression. These relationships were significant after the effect of other variables was removed. An independent samples t-test revealed a significant difference in 2D:4D between individuals from contact (M=.94, SD=.033) and non-contact (M= .95, SD=.033) sports: t (173) = -2.68, p=.008. A one-way ANOVA reported a significant difference in 2D:4D means across all sporting groups: F (7, 192) = 3.706, p =.001; post-hoc analysis revealed these differences to lie between: the boxers and the badminton players; the rugby and the badminton players; and the non-sporting group and the boxers.

Discussion

This study included a sample of both athletes and non-sports people in order to examine associations between prenatal testosterone (2D:4D), self-reported psychological aggression, choice of sport (contact vs. non-contact), attainment level within sport, and longevity (number of years involved in sport). Firstly, the study showed that individuals involved in sport exhibited significantly greater levels of prenatal testosterone (lower 2D:4D) and greater levels of physical aggression compared with their non-sporting counterparts. This replicates the findings of previous studies within the sports of football (Perciavalle et al., 2013) and rugby (Bennett et al., 2010). In order to determine reasons for the choice of sport among the athlete group, subjects were split into two dichotomous groups: contact sports and non-contact sports. Findings showed that athletes from contact sports (rugby, football and boxing) were found to have significantly lower 2D:4D and significantly higher levels of physical aggression compared to athletes from non-contact sports (basketball, golf, weight-training, badminton).

Additional findings included significant, negative relationships between 2D:4D and self-reported levels of physical and verbal aggression, i.e., those with lower 2D:4D ratios self-reported high levels of aggression. Along with number of years involved in competitive sport, the most significant ($p < 0.01$) relationship with 2D:4D was that of physical aggression. Therefore, the findings of this study suggest that physical aggression (direct physical contact) is related to prenatal exposure to testosterone. This finding supports that of previous research conducted on individuals presenting 'boxer's fractures' as a result of aggressive encounters recording significantly lower 2D:4D ratios compared to normal populations (Joyce et al., (2013). Perhaps the context of sport allows for the manifestation of physical aggression more readily, particularly in contact sports where a level of physical contact is necessary. This would support the findings of Ribeiro et al (2016) who recorded more acute measures of testosterone (via saliva samples) in order to show marked spikes in the male hormone of low 2D:4D individuals directly following aggressive encounters in contact sports.

When considering aggression levels, 2D:4D and attainment level, a significant interaction effect emerged. Specifically, for athletes competing at international and national levels, those with high 2D:4D (low levels of prenatal testosterone) reported high levels of hostility in comparison to those with low 2D:4D. Whereas at regional level, those with low 2D:4D self-reported comparably higher levels of hostility. The finding that those with high 2D:4D report higher levels of hostility is consistent with the results of Golby &

Meggs (2011) who reported similar findings in a heterogeneous sport sample. The finding that this effect is different at regional level is somewhat surprising. Perhaps, at this level of sport there is a presence of some level of pressure (but not as high as it might be at international level) which could bring about some negative emotional consequences that may result in hostility. Those with low 2D:4D have previously been reported to be more competitive, more determined to succeed, and have a greater belief in their abilities to be successful (Golby & Meggs, 2011). If they are unable to translate that desire for success into a reality of success (e.g. by progressing to national/international level of competition) then perhaps this brings about an increased level of negative emotional outcomes and hostility. This finding warrants further research attention to explore the nature of the effect.

Regarding the topic of longevity, findings showed that those exposed to higher levels of prenatal testosterone (low 2D:4D) had been involved in sport for more years compared to those with high 2D:4D, adjusting for age. This finding supports that of Coates et al. (2009) who found low 2D:4D to be predictive of longevity within financial traders. Therefore, in highly stressful contexts such as sport and business, perhaps exposure to prenatal testosterone provides a buffer against burnout. This is particularly important when considering the wealth of funding devoted to the careers of top performing athletes and the limited number that go on to have careers lasting longer than ten years (Burgess, Naughton & Hopkins, 2012). Baker et al. (2013) highlighted numerous variables that have been previously hypothesised to predict sporting longevity, including: body mass index (BMI); past family history of disease; self-confidence; team cohesion; and motivation. However, most of the variance in sporting longevity remains relatively unexplained (Barker et al. 2013). Therefore this study's finding of a significant association between prenatal testosterone and sporting longevity may prove important if successfully replicated across a greater variety of sports within future studies.

This study provides further support for the proposal that prenatal testosterone has a permanent masculinising effect on the sporting brain (Hönekopp, 2011) within a relatively large sample of athletes and non-athletes. However, several limitations should be taken into account. Firstly, the study design is cross-sectional in nature and therefore cannot determine the stability of the measured relationships. Future studies adopting prospective designs would be a useful extension of the current study. Secondly, direct measures of digit lengths may provide more reliable data than photocopies (Bennett, et. al., 2013). Thirdly, all of the testing (questionnaires and hand scans) for the current study were carried out at 'neutral' times, i.e. not directly before, during or after training or competition. This was true for all except the golfing group: for whom, due to limited availability of the players, testing took place directly after a regional competition. Tahkur and Ghosh (2013) proposed that competition can impose a significant effect on levels of circulating testosterone thus directly affecting levels of self-reported aggression. Tahkur and Ghosh (2013) found pre-competitive aggression levels of national standard male yoga performers to be significantly higher than post-competition levels. Therefore future research should endeavour to ensure continuity of testing across sporting groups in order to maintain reliability.

Finally, previous research into the relationship between 2D:4D, key psychological variables and performance has often included samples of elite athletes (Perciavalle, et. al., 2013; Bennett, et. al., 2010). The current study used 'non-professionals' therefore labelling each participant as a '*boxer*' or '*weight-lifter*' became more contentious. Many of the individuals (approximately 15% of the 175 'sporting athletes') at the time of testing regularly took part in more than one sport and were therefore forced to select the one they had been doing the longest. It could therefore be suggested that this is not necessarily a fair reflection of which one they most associated themselves with. Additionally, certain participants who had previously been regularly involved in a certain sport but were not regularly training at the time of testing thus became part of the non-sporting group; however, does this single factor make them 'non-athletes'? Arguably, what an individual does in his spare time still requires choice (Rottensteiner, et. al., 2014) and therefore the results of this study may still validly contribute to our overall understanding of sport choice. However, if future studies intend to work with non-professionals this issue of labelling highlights the need for the procurement of further information, potentially via the use of semi-structured interviews or additional surveys regarding the participant's exercise history (Whiting, 2008).

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