The organizational effect of prenatal testosterone upon gender role identity and mental toughness in female athletes

ABSTRACT

Research has identified a correlation between prenatal markers of testosterone (2D:4D) and sport performance. This relationship is thought to be explained by several important psychophysiological variables such as physical fitness and mental toughness. The current study sought to add to this body of research by examining the relationship between 2D:4D, a measure of gender identity (BSRI) and mental toughness (MTQ48). A sample of 113 recreational (n= 61) and competitive netballers (n= 52) completed the psychological measures and provided right-hand scans from which 2D:4D ratio measures were drawn. The key results included that those competing at the highest levels of competition had lower 2D:4D, higher levels of mental toughness and a stronger identification with both masculine and feminine traits. These findings suggest that 2D:4D could provide a marker for sporting potential and mental toughness in female sport participants. However, future research may wish to establish the relative contribution of prenatal factors (such as 2D:4D) and socialisation factors (involvement in a sporting context) on sporting ability and related psychological variables.

INTRODUCTION

There have been research developments around individual differences in biological markers of hormonal development. There are several sources of evidence to suggest that the 2D:4D ratio is an indicator of fetal sex hormones such as testosterone and

oestrogen. The 2D:4D ratio is a putative marker of prenatal testosterone exposure that has been utilized as an important non-invasive biomarker in research. First, these sex differences in 2D:4D are already observable at the end of the first trimester of fetal development and individual differences appear to emerge prenatally (Malas, Dogan, Evcil & Desdicioglu, 2006) which are fairly stable during postnatal growth (Trivers, Manning & Jacobson, 2006). Second, the second digit growth is stimulated by oestrogen and the fourth digit by testosterone (Manning, 2002) and sex differences in 2D:4D are unaffected by puberty (Manning, Scutt, Wilson & Lewis-Jones, 1998). Researchers have suggested possible causal factors for these differences including; sex steroids could influence relative bone lengths by facilitating the development of phalangeal anlagen during the perinatal period or metaphyseal growth. Alternatively, sex differences in digit ratios could arise if bones from different fingers are differentially receptive to sex steroids or if the bones of different fingers have similar responses to sex steroids but differ in their temporal pattern of growth. However, it should be noted that specific direct evidence in terms of the short finger bones is lacking (McIntyre, 2006). Taken together, research has supported 2D:4D ratio as a viable biological marker of developmental processes (Manning et al., 1998). It would logically follow that 2D:4D would be negatively associated with sex role orientation. However, this prediction has yielded inconsistent findings; some small-sample studies have found this predicted effect (e.g., Beech & Mackintosh, 2005) with other large-scale studies (e.g., Lippa, 2006) not finding the expected effect. However, it should be considered that some of these null findings may be due to differences in task specific factors (e.g. sensation seeking; Voracek, et. al., 2010, spatial ability; Puts, et. al., 2008). Nevertheless, Voracek, et. al. (2011) maintained that associations between 2D:4D and sporting ability remain worthy of further consideration.

Therefore, one avenue of research that has sought to explore the relationship between 2D:4D and sex-role orientation is to examine sporting performance. This is because the nature of sport performance is that male-typical physical and psychological qualities (e.g., strength, cardiovascular capabilities and psychological toughness) are beneficial for success.

Previous research using males has highlighted that individuals with low 2D4D's typically perform better in sports (Manning & Taylor, 2001), e.g., studies have shown that to be the case in sports such as fencing (Voracek, Reimer & Dressler, 2006), rugby (Bennet, Manning, Cook & Kilduff, 2010), male surfing (Kilduff, Cook & Manning, 2011) and american football (Schorer, Reinhoff, Westphal & Baker 2013). Similar findings have been shown with female samples, e.g., Hull, Schranz, Manning and Tomkinson (2015) found that lower 2D:4D ratios were indicative of faster race times in national level rowers. Moreover, Paul, Kato, Hunkin, Vivekanandan, & Spector (2006) also found a negative association between digit ratio and running performance in females. Some meta-analyses have reported similar trends. For example, Honekopp and Schuster (2010) collected data from several studies and included data of 2,810 right hand and 2,791 left 2D:4D ratios, finding that athletic performance was negatively linked to 2D:4D in both hands. More recent research such as a study by Frick, Hull, Manning & Tomkinson (2017) has found that those competing at higher levels in basketball leagues have lower 2D:4D. However 2D4D was not meaningfully related to game-related basketball statistics in national-level players. Another study by Ribeiro et al. (2016) has found that low 2D:4D is indicative of better performance in challenging strength task conditions. This suggests that the role of prenatal testosterone in influencing performance is particularly evident when under pressure. However, this interpretation should be treated with caution as studies have reported equivocal findings;

i.e., some studies have found negative correlations between 2D:4D ratio and masculinity in male samples (Vorecek, et. al., 2011). Research has also sought to identify the underpinning psychological variables that may explain this athletic bias. For example, Golby and Meggs (2011) showed that those with lower 2D:4D reported higher levels of optimism, task and ego goal orientations and mental toughness.

Mental toughness is thought to be a collection of cognitive, affective and behavioural characteristics (a psychological resource) that allow an individual to manage the stressors of competition and perform well (Gucciardi, Gordon & Dimmock, 2008). The characteristics of mental toughness include control (feeling in control of one's emotions during a netball match), confidence (having belief in one's ability to achieve a successful pass/shot), challenge (perceiving netball competition to be an opportunity for success and skill improvement) and commitment (being immersed in the sport and attending training or a commitment to values and excellence in netball). It appears that such characteristics would enable a netballer to perform successfully. There is some on-going debate as to whether mental toughness is a trainable construct or a stable and enduring trait. For example, research by Connaughton, Wadey and Jones (2008); Connaughton, Hanton and Jones (2010); Coulter, Mallett and Gucciardi (2010); Gucciardi, Gordon and Dimmock (2009) and Thelwell, Such, Weston, Such, and Greenlees (2010) all suggest that specific aspects of mental toughness can be potentially developed and taught in a sporting environment. Having said this, it still remains an important avenue to identify biological markers of mental toughness so that individual differences can be identified. Biological markers can identify the potential for mental toughness development and consider the effect of socialization upon these biological underpinnings. For example, those with low

2D:4D may demonstrate a greater propensity for mental toughness development (Golby & Meggs, 2011) but those with high 2D:4D could possibly be targeted for assistance with psychological skills training programs to develop mental toughness.

Previous research has found that males demonstrate higher levels in all mental toughness subscales (Andrews and Chen, 2014; Nicholls, Polman & Levy, 2009) compared to females. However, male and female categorization as a dichotomous split may be limited in that males and females can differ as to how they identify with the male or female stereotypical norms. In keeping with this notion, research has sought to identify if 2D:4D is linked with gender identification (i.e., the extent to which men and women identify with masculine or feminine stereotypes). Csatho et al. (2003) investigated this association with 46 female students and found that those with lower, more male typical digit ratios scored higher on the masculinity subscale of the Bem Sex Role Inventory (BSRI, Bem 1981). However, the findings of Csatho, et. al. (2003) were not subsequently replicated in a similar sized sample (Vorecek et al, 2011). In other research, Rammsayer and Troche (2007) administered the German adapted BSRI to 432 male and 312 female participants and found that males scored higher on the masculinity subscale and females on the femininity subscale. However, no significant relationships were identified between female 2D:4D and BSRI scores, whereas it was found that males with low 2D:4D self-reported lower scores on the femininity subscale.

There remains a dearth of research of female participants when examining 2D:4D and psychological traits, therefore a female sample of athletes were chosen in this study. Netball players have likely been exposed to playing their sport from a young age in

secondary education and therefore provided an opportunity to study women who have been socialized in a sporting context. Moreover, a sport-specific sample was selected as mental toughness could be partially context specific (Crust, 2007; Gucciardi, 2017). , Firstly, this study aimed to explore the relationships between 2D:4D, mental toughness and gender role identity. Secondly, the study aimed to explore the differences in mental toughness and gender role identity between netball players in different competitive standards and those with high and low 2D:4D. In line with previous research, the first hypothesis predicted that those with low 2D:4D would report significantly higher levels of mental toughness, lower levels of femininity and higher levels of masculinity than those with high 2D:4D (Golby & Meggs, 2011). The second hypothesis anticipated that those netballers competing at the highest levels of achievement will demonstrate lower 2D:4D ratio, higher mental toughness levels and masculinity.

METHOD

Design

The study employed a cross-sectional, descriptive research design. The between subject factors were competition standard with two levels: recreational and regional/national level and digit ratio with high and low levels. The dependent variables were mental toughness and gender role identity.

Participants

The participants were 113 female netballers (Mean age = 22.34, S.D. = 2.23) from North Yorkshire who were either competing at a local, recreational level (n = 62) or at regional/national standard (n = 51). The majority of the participants were right handed (n = 81).

Measures

MTQ48 mental toughness measure

The 48-item version of the Mental Toughness Questionnaire (MTQ48; Clough, Earl & Sewell, 2001) measures mental toughness in total as well as having six individual subscales; challenge ('*Challenges usually bring out the best in me'*), commitment ('*I can generally be relied upon to complete the tasks I am given'*), emotional control ('*I tend to worry about things well before they actually happen'*), life control ('*I generally feel in control*'), confidence in own abilities ('*I am generally confident in my own abilities'*) and interpersonal confidence ('*I am comfortable telling people what to do'*). The traits are measured on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire has been found to be a robust psychometric measure of mental toughness (Perry, Clough, Crust, Earle & Nicholls, 2013). The internal consistency of the MTQ48 has been previously investigated with results finding that the overall Cronbach's Alpha value is 0.87 with scores ranging between 0.58 and 0.71 (Nicholls, Polman, Levy & Backhouse, 2009). Clough et al. (2002) provided evidence for the construct validity of the MTQ48 with significant relationships reported with optimism (r = 0.48), self-image (r = 0.42), life satisfaction (r = 0.56), self-efficacy (r = 0.68) and trait anxiety (r = 0.57). In respect of criterion validity, Clough et al. (2002) found participants with self-reported high, as opposed to low

mental toughness gave lower rating of exertion during a 30-minute physically demanding cycling task. The MTQ48 has also been found to correlate with pain tolerance (Crust & Clough, 2005).

BSRI gender role self-report measure

The Bem Sex Role Inventory (BSRI; Bern, 1981) is a self-report which measures how the respondent fits into gender stereotypes of masculinity and femininity. It operates on the basis that masculinity and femininity are both within the psychological androgyny rather than the previous assumption that both traits were at opposed ends of a single dimension. The BSRI (full version) has 60 personality characteristics which are measured on a Likert scale ranging from 1 (never or almost never) to 7 (always or almost always true). Of the 60 personality characteristics 20 assess masculinity (e.g. assertive, willing to take risks), 20 assess femininity (e.g. compassionate, gentle) and 20 are fillers (e.g. moody, jealous) which have no scoring value. The internal consistency of the sub traits has been assessed; the Cronbach's alpha for the masculine subscale is 0.87, feminine is 0.77 and 0.64 for the fillers (Gaunt, 2006). The internal validity of the measure has been deemed to be adequate (Holt & Ellis, 1998).

Digit ratio measure

A portable flat-bed scanner was connected to a laptop to take scans of the participant's right hands. The 2D:4D ratio was created using the digit ratios which were measured using Vernier calipers; accurate to 0.01mm (Manning, et. al., 1998).

Procedure

Prior to data collection ethical approval was granted by Sheffield Hallam University ethics committee. Next, six local netball clubs were contacted to explain the aims and expectations of the study and obtain consent. Following this, individual participant

consent was obtained and a competition tournament was attended where participants were invited to provide digital hand scans of their right hands (using standardised instructions of; “please remove any jewelry and to place their hand gently onto the flatbed scanner” and complete the MTQ48 and BSRI measures (in that order) in a private room on site. Participants were thanked for their involvement in the study and provided with a full debrief on completion.

Data analysis

Using calculations based on the normal distribution and Cohen’s d effect size guidelines (Rosner, 2010) a retrospective power-analysis with a small effect size of 0.2 (Cohen, 1988), $\alpha = 0.05$ and $N_1 = N_2 = 56$ revealed a statistical power estimate of 0.18. . Thus by conservative estimates the current study appears underpowered. Descriptive statistics for the two factors of competition standard (competitive and recreational) and digit ratio (high and low) for each subscale are shown in Table 1. Digit ratio was categorized into high (>0.98) and low (<0.98) groups utilizing a median-split. Such an approach was used by Golby & Meggs (2011). It is difficult to draw from group norms from other studies as they differ in terms of gender, cultural and sporting characteristics. These factors have been shown to be related to 2D:4D, e.g., males, caucasian people and high performing athletes all have lower digit ratios.. A Pearson’s correlation was done to investigate the association between gender role (femininity and masculinity) and mental toughness (Table 2). A two-way between subjects MANOVA was conducted to explore the differences in mental toughness and masculinity between competition standard (recreational and competitive) and digit ratio (high and low). The multivariate and univariate significance values and effect sizes are reported in Table 3. The partial eta squared effect sizes are interpreted using the following guidelines; 0.01-0.059

(small), 0.06-0.129 (medium) and 0.13 + (Large) (Cohen, 1988). With two predictor variables, the effect size descriptors of eta squared can be applied to partial eta squared (Levine & Hullet, 2002). The data was found to satisfy all parametric assumptions prior to the inferential analysis including normal distribution (Kolomonogrov-Smirnov statistic; $p>0.05$). The inter-rater reliability (the relationship between the measurements taken by two independent researchers) of right hand 2D:4D ratio was high ($r=0.98$).

RESULTS

Descriptive statistics (Table 1) revealed differences in challenge between those competing at '*competitive*' ($M = 4.15$, S.D.:0.77) and '*recreational*' ($M = 3.97$, S.D.:0.24) levels of sporting competition. There werealso differences in masculinity between those competing at 'competitive' ($M = 108.67$, S.D.: 10.98) and 'recreational' ($M = 109.5$, S.D.: 7.38) levels. Pearson's correlation analysis (Table 2) revealed significant relationships between mental toughness subscales ranging between $r=0.65$-0.84 ($p<0.05$). Moreover, there were significant, moderate, positive correlations between masculinity and subscales of mental toughness; challenge ($r= 0.40$, $p <0.05$), commitment ($r= 0.32$, $p <0.05$), emotional control ($r = 0.31$, $p <0.05$) and confidence in abilities ($r= 0.33$, $p < 0.01$). The MANOVA (Table 3) showed a large multivariate effect for right hand digit ratio, Wilks $\surd = 0.634$, $F (1, 112) = 7.5$, $p < 0.001$, partial $n_2 = 0.366$. There was also a large multivariate effect for competition level, Wilks $\surd = 0.81$, $F (1, 112) = 3.09$, $P < 0.005$, partial $n_2 = 0.19$ and further univariate ANOVA results are shown in Table 3. Those netballers competing at a national standard self-reported higher levels of challenge and masculinity than those competing at recreational level, however the effect size was small. There was no

significant interaction between digit ratio and competitive level. There were significant differences in all variables between those who have low and high digit ratio ratings. Differences between athletes at each competitive standard in terms of interpersonal confidence and life control showed the largest effect sizes with challenge and confidence in abilities showing the smallest effect sizes.

Table 1: (insert here)

Table 2: (insert here)

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

Table 3: MANOVA and Univariate results for the right hand digit ratio and competition level main effects

Main effect/Variable	Wilks √	DoF / F ratio	p value	Partial η_2	Descriptor
Right hand digit ratio	0.634	F(1,112) = 7.5	p < 0.001	0.366	Large
Challenge		F(1,112) = 4.34	p < 0.05	0.037	Small
Commitment		F(1,112) = 5.86	p < 0.05	0.05	Small
Emotional control		F(1,112) = 29.28	p < 0.001	0.207	Large
Life control		F(1,112) = 32.9	p < 0.001	0.23	Large
Confidence in abilities		F(1,112) = 4.49	p < 0.05	0.039	Small
Interpersonal confidence		F(1,112) = 43.62	p < 0.001	0.28	Large
Masculinity		F(1,112) = 24.40	p < 0.001	0.179	Large
Femininity		F(1,112) = 5.014	p < 0.05	0.043	Small
Competition level	0.81	F(1,112) = 3.09	p < 0.001	0.19	Large
Challenge		F(1,112) = 3.19	p < 0.05	0.028	Small
Masculinity		F(1,112) = 4.22	p < 0.05	0.036	Small

DISCUSSION

Previous research has identified and supported a relationship between finger digits (growth of the 4th finger) and levels of prenatal testosterone (Manning, 2002). The first aim of this study was to identify the relationships between 2D:4D, mental toughness and gender role identity. The first hypothesis predicted that those with low 2D:4D would report significantly higher levels of mental toughness, lower levels of femininity and higher levels of masculinity than those with high 2D:4D. As expected, a low 2D:4D right

hand digit ratio was typical of those with higher levels of challenge, commitment, confidence in abilities, emotional control, life control and interpersonal confidence. However only the last three of these subscales had medium to large effects compared to the others that were only small. Its interesting that two of the three medium to large effects – life control and interpersonal confidence - can be interpreted as social-psychological variables (the relational aspects of mental toughness). It may be that a lower digit ratio is associated with characteristics that enable individuals to remain in pursuit of their goals (Gucciardi, Gordon & Dimmock, 2008) in this female sample. These results are consistent with other findings using a female sample that have also found a negative relationship between 2D:4D ratios and mental toughness. The findings support those of previous research that had identified the organisational effect of prenatal testosterone upon the sporting brain (Golby & Meggs, 2011; Reed & Meggs, 2017). Specifically, those with low 2D:4D have been shown to have higher levels of determination (conceptually similar to commitment), self-belief (confidence) and positive cognition, i.e., challenge (Golby & Meggs, 2011). This also underlines the need to identify the links between 2D:4D and gender identification. This finding suggests that within females, there is important variability in the extent to which individual members identify with masculine traits and this may encourage these individuals to expose themselves to situations that develop mental toughness (sporting situations) more often than females with higher digit ratios. Indeed, the difference in masculinity between high and low digit ratio had a large effect size, compared to a small effect for femininity in the predicted direction. This indicates that the concept of gender self-identification is important when considering psychological attributes relevant for sport performance.

It is important to note that Voracek, Pietchnig, Nader & Stieger (2011) found that men's left-hand 2D:4D related positively to masculinity scores, which is counterintuitive. However, such findings cannot necessarily be generalized to the females in this sample.

223 However, as prospective power analysis reveals that the current study is underpowered, there is the possibility that these effect sizes
224 are inflated (e.g., Csatho et al, 2003).

225 A Pearson's correlation revealed that those with higher levels of mental toughness were significantly higher scoring in terms of
226 both masculine and feminine stereotypical traits. This gender profile whereby individuals identify strongly with both feminine and
227 masculine traits is typically termed 'androgynous' (HiroKawa, Yamada & Dohi, 2001). This profile could indicate identification with
228 traits associated with emotional intelligence, such that an individual is able to identify their own and others emotions and manage
229 them effectively in a team sport environment (Rutkowska & Bergier (2013). For example, Hirokawa et al, (2001) in a laboratory
230 study, found that both females and males experienced a reduction in stress levels when in conversation with an androgynous partner
231 compared to a sex-typed partner. This reduction in stress is thought to be a function of the interpersonal skills of the androgynous
232 individual. Other researchers have argued that androgynous individuals could be better equipped in terms of interpersonal adjustment
233 than other groups (Johnson & Brems, 1989; Petry & Thomas, 1986). Rutkowska & Bergier (2013) found that androgynous female
234 soccer players scored significantly higher in emotional intelligence compared to a sex typed female sample. Such identification with
235 traits such as competitiveness and assertiveness are likely to prove an advantage in a sporting context also.

236 The second hypothesis was that netballers at a competitive level would demonstrate lower 2D:4D ratios, higher mental
237 toughness and masculinity compared to recreational players. This hypothesis was also supported. Moreover, those netballers who
238 were currently playing in competitive regional or national leagues self-reported only slightly higher levels of challenge and

masculinity over those who were competing at a recreational level and therefore the practical benefit of this is unknown. Research elsewhere has found that high levels of masculinity are related to high levels of mental toughness (in both boys and girls) and the importance of socialisation and gender roles have been highlighted (Strycharcyk & Clough, 2014). Tentatively, this finding suggests that prenatal factors (such as hormonal exposure) could present a potential for identification with masculine traits, of which one is mental toughness. Specifically, in women, a lower 2D:4D ratio is associated identifying with male stereotypes. It is likely that environmental experiences are likely to either amplify or dampen the influence of prenatal hormones upon gender role identification in adulthood. In sport, women are exposed to stereotypically male behaviours, such as competition and aggression although it is not known to what extent those experiences are an outcome or a consequence of higher levels of mental toughness. Further research is needed to breakdown the antecedents of mental toughness differences at different levels of sport within females. These results are similar to previous studies that have shown increased mental toughness at higher levels of competitive experience (Chen & Cheesman, 2013) but goes beyond those studies by indicating a link with a potential biomarker. The findings from this study support the development of a potential talent biomarker (2D:4D) and support this suggestion from previous studies e.g., Meggs & Golby (2011). With further research a better understanding of the biological contribution to sporting success and key psychological variables can be established along with the nature of socialization. If mental toughness is developed by involvement in the sporting environment (exposure to 'masculine' traits such as competitiveness and independence) then competitive sport could be an arena wherein resilience to stress can be cultivated. These findings suggest that those with low 2D:4D may be particularly able in a sporting context and 2D:4D could be a potential proxy marker for future potential or success in netball.

There are some limitations to this study. Firstly, there was no current performance measure assessed and therefore the relationship between 2D:4D and on-going performance level is unknown. This limits the comparison of the present findings to the studies of Hull, et. al. (2015) and Paul, et. al., (2006) who did assess current performance. Secondly, although mental toughness differences were found within digit ratios some of the subscale effects were small and it is unknown to what extent these variables would help deal with competitive stressors. Perhaps future research may wish to assess the interaction between prenatal hormone exposure, childhood experiences (in terms of socialisation with gender stereotypes) and mental toughness levels. It appears logical that those who identify with masculine traits would also self-report high levels of mental toughness; as the characteristics of mental toughness (i.e., independent, stubborn mindedness, and determination to succeed) are typically associated with a masculine stereotype (Strycharcyk & Clough, 2014). Whether this identification is a result of prenatal hormone exposure or socialisation, or an interaction between the two, is yet to be fully explored. The nature of a sport is an integral part of an athlete's socialisation and therefore male dominated sports such as football and rugby may lead to different gender identifications in women. Future research may wish to explore the association between gender role identification, 2D:4D and mental toughness in male dominated sports. Moreover, the cross-sectional nature means that the stability of these relationships cannot be explored; prospective studies would allow mental toughness and gender role identification to be predicted from 2D:4D ratios. It may also be worth exploring if females with higher digit ratios have similar coping strategies when dealing with competitive stress compared to males. Lastly, the research can only be considered in the social context of netball, perhaps future research may wish to explore the nature of these relationships in various sports. Although previous research has highlighted coping differences between the genders on average, this does not take into account

the variation on pre-natal hormone exposure which may indicate high levels of masculine identification in females with high digit ratios. Finally, the inclusion of a median-split of 2D:4D limits the generalizability of the findings. Future research may wish to develop established group norms for specific sub-groups so that a universal categorization of 2D:4D into high and low categories is possible.

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