

Preliminary study: Digit ratio (2D:4D) Among U20 male and female rugby sevens state players

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Abstract:

There have been a few studies linking digit ratio (2D:4D) to aggressive sports that requires frequent physical contacts; however, it is uncommon to find studies including both male and female rugby sevens players with 2D:4D. Due to the link established on the status of 2D:4D with participation in sports in most studies, this study focuses on rugby sevens to compare the prevalence of 2D:4D in U20 male (n = 36) and female (n = 36) rugby sevens state players with that in non-athletes (male, n = 40; female, n = 40). The participants were selected using a purposive selection method; all of the samples were state representatives and non-athletes. For the 2D:4D assessments, 2D:4D was measured and calculated using a measuring software and a scanner equipment. The analysis revealed that both genders in the rugby group had low 2D:4D scores, whereas those in the non-athlete group had higher 2D:4D scores (male, $M \pm SD = 0.993 \pm 0.034$ mm; female, $M \pm SD = 1.020 \pm 0.032$ mm). Furthermore, the rugby group had reduced low 2D:4D readings (male, $M \pm SD = 0.938 \pm 0.026$ mm; female, $M \pm SD = 0.960 \pm 0.039$ mm). The results of the independent t-test demonstrated a significant difference in 2D:4D for both hands between male and female rugby players and the non-athletes ($p = .000$). This indicated that low 2D:4D is substantially associated with high prenatal testosterone content, leading to aggressive behavioral traits and participation in competitive sports that include lots of physical contact, as observed in rugby sevens players with no regard to gender difference. In conclusion, this knowledge could provide better understanding of the role of 2D:4D in athlete selection, as well as the relationship of prenatal testosterone on aggression and masculinity in contact sports.

Keywords: Digit ratio, prenatal testosterone, aggression, rugby sevens

Introduction

The digit ratio is the ratio between the lengths of the second (index) and fourth (ring) fingers, commonly known as 2D:4D in related studies. It is sexually dimorphic (Manning et al., 2000; Reed et al., 2017), with male and female showing different traits. Every human body produces two sex hormones, namely, testosterone, regarded as a male-like hormone, and estrogen, associated with femininity. The second digit (2D) of females is much longer than their fourth digit (4D), and their digit ratio (2D:4D) is high. On the other hand, the 2D of males is lower than their 4D (Hönekopp and Watson, 2011; Rammsayer and Troche, 2007). In addition, high prenatal testosterone and low estrogen levels are associated with low 2D:4D, whereas low prenatal testosterone and high estrogen levels are associated with high 2D:4D (Rammsayer and Troche, 2007; Van Hemmen et al., 2017). These findings are consistent with those of previous studies, which concurred that females had higher 2D:4D than males due to the higher amount of testosterone acquired while in the mother's womb. Both sex hormones influence 2D:4D development in that testosterone boosts 4D prenatal growth and estrogen encourages 2D development. Manning et al. (1998) and Voracek and Loibl (2009) demonstrated that the formation of testosterone, estrogen, or both hormones obtained during the embryonic stage determines whether an individual is more masculine or feminine. They further demonstrated that 2D:4D is sexually dimorphic, and this finding was enhanced by Galis et al. (2010) and Voracek et al. (2011), who correlated 2D:4D with physical and behavior traits between the genders.

The formation of human fingers occurs in the mother's womb. As early as the 14th week of intrauterine life, the polarity of finger development appears and remains stable until puberty (Galis et al., 2010; Hines et al., 2015). They further stated that starting at the age of 2 years, the 2D:4D ratio from sexual dimorphism is stable, and there is no evidence of change in the 2D:4D ratio at puberty. This is supported by the findings of Manning et al. (2000) and Voracek (2011). High levels of testosterone influence the development of the cardiovascular and muscular systems in humans (Holzapfel et al., 2016; Lutchmaya et al., 2004). Thus, due to high prenatal exposure to testosterone, there is a clear association between a high 2D:4D ratio in both hands and excellent

performance in endurance (Carlos dos Santos, 2019; Holzapfel et al., 2016) and explosive (Bennett et al., 2010; Hsu et al., 2018; Tamiya et al., 2012) sports. Therefore, individuals with good cardiovascular system and strong muscles tend to have good sports capabilities. The various studies on 2D:4D as a potential reliable biomarker demonstrated a link between 2D:4D and psychology, fertility, diseases, and, most importantly, athletic performance (Cleveland, 2014; Kim and Kim, 2016; Lu et al., 2012; Mackus et al., 2017; Pasanen et al., 2021). Previous research (Eler, 2018; Nanda and Samanta, 2017; Ranson et al., 2015) also showed data on the negative relationship between various physical exercise testing scores and 2D:4D. Thus, majority of the research predicted that the digit ratio would be a long-term predictor of prenatal androgen consumption and response. Thus, this ratio is also strongly associated with high achievement in sports [24], as explained further by Tester and Campbell (2007) and later on by Kim and Kim (2016), who suggested that 2D:4D is correlated with high performance and attainment of elite athlete status in various sports.

In terms of 2D:4D sports, rugby sevens is a naturally aggressive sport with a pattern of play that is much faster, agile, and fast-paced, with quick bursts, sudden stops, and less body contact than rugby union (Higham et al., 2014; Suarez-Arrones et al., 2014), as well as a much shorter match time, i.e., 7 min played for two separate halves. The emotional backdrop of this rugby sport, as well as the fact that it combats sports and contact sports, contributes to its aggression. Various contact sports are associated with aggressiveness, demand great physical strength and other biomotor talents, and are linked to high prenatal testosterone level; examples of these sports are rugby (Azam et al., 2019; Bennett et al., 2010), football (Manning & Taylor, 2001), sumo (Tamiya et al., 2012), fencing (Voracek et al., 2010), and Greco-Roman wrestling (Keshavarz et al., 2017). In addition, lower 2D:4D ratio was also observed in other combat sports such as karate, taekwondo, kick-boxing, and judo (Adamczyk et al., 2021) as well as boxing (Reed et al., 2017). Given that there are sufficient evidences on the association between 2D:4D and prenatal testosterone content, aggression, and participation in competitive sports, the idea of establishing 2D:4D in rugby sevens for both genders should be considered. Bennett et al. (2010) claimed in their study on elite English rugby players that rugby players have significantly low 2D:4D, and those with a low 2D:4D reported excellent sport performance. The closest study in rugby sevens and 2D:4D was by Azam et al., (2019) that demonstrated Malaysia's male national rugby sevens team had low 2D:4D, and they won the gold medal at the 2017 SEA Games. This led to them being crowned as the rugby sevens champion in the region of Southeast Asia. This further indicates that in contact sports, such as rugby, high-risk/contact-sport, athletes have greater testosterone levels than low-risk/noncontact-sport players (Hönekopp and Schuster, 2010; Kim and Kim, 2016; Kociuba et al., 2017); they also achieve more than the others (Eklund et al., 2020; Pokrywka et al., 2005). The same can be said about Hönekopp's key findings (Hönekopp & Schuster, 2010), which associated low 2D:4D with testosterone traits of aggression, masculinity, and high physical fitness, which are a must-have traits for rugby sevens players to be able to achieve excellent performance.

Most studies have demonstrated that males have higher performance levels in sports and fitness tests than females (Ranson et al., 2015; Zheng and Cohn, 2011) because the high testosterone level among males is usually much more visible than among females and is more advantageous for males in terms of sports participation. These progressions are proportional to each gender even if the performances still improve. As further discussed by Kociuba et al. (2017), sports with a high-risk of injury, such as judo or boxing, have lower 2D:4D than aerobic sport in females. They also stated that females with high testosterone level are those who are involved in high-risk sports that are often dominated by males. These variations in female athletes may be associated with different levels of prenatal testosterone (Lombardo et al., 2018), which suggests that lower 2D:4D does not discriminate female athletes in terms of aggressive sports participation.

Nevertheless, studies relating 2D:4D and rugby sevens is quite scarce, and the inclusion of female athletes is lacking. It is also interesting that some of the previous studies were not able to find a relationship between 2D:4D and performances in physical fitness testing and sports (Eghbali, 2016; Peeters et al., 2013). This questions the reliability of 2D:4D as a potential predictor of performance in sports or for identifying sports talent. Aside from the lack of related studies, as aforementioned, rugby sevens has been used as the main sport in this study because it is a physically demanding sport with frequent aggressive physical contacts. Furthermore, it has become a popular option of sports lately due to its rise as mainstream sport at the international stage with its recent inclusion in elite competitions, such as Olympics and Commonwealth Games. Therefore, relating to the nature of rugby sevens itself (aggressiveness, competitiveness, explosive movements, physical strength) that is associates with the traits of 2D:4D, this study aimed to identify the relationship of 2D:4D status between male and female rugby sevens state with the non-athlete group in order to provide better understanding on the issue.

Materials and Methods

Participants

For this study, the participants were divided into two groups: the rugby group and the non-athlete group. For rugby group a total of 72 rugby sevens players ($n = 72$) makes up from 36 male players and 36 female players representing their state in U20 rugby sevens state teams competing in a national rugby sevens side competition. Meanwhile, the non-athlete group consisted of individuals (40 males and 40 females, $n = 80$) that do not play rugby and did not engage in any sports, did not join in any sports competition, and had body mass index in the normal range were included in this study.

Permission to conduct data collection was obtained from the competition director before the competition started. Moreover, the state team managers and coaches were provided informed consent letter and gave their approval. The age range of both groups was 18–20 years old. Participants who reported any injuries or deformities, especially in the hands, fingers, palms, or arms, were excluded from the study, as well as participants who reported being sick. For information, this study was approved by the research ethics committee of the Universiti Teknologi MARA Pahang Branch.

Measurement of the Digit Ratio

At the start of the 2D:4D measurement, the participants were asked to check if their hands were clean, wipe off any dirt, and remove any accessories, such as watch and ring. This study employed the indirect measurement and used a scanner (Canon CanoScan LiDE 120), with a resolution of 2400×4800 dpi. In the seating position, the participants were asked to straighten and evenly spread their fingers and then gently place their palm on the scanner. It is important for the participants not to put too much force on the palm as it may distort the soft tissues of the finger, thus making it bigger and longer. Once the hand scanning procedure was completed, the images of the hand were saved in the laptop. The images were then opened in MicroDicom viewer (version 3.7.9) for measuring the length of the finger and calculating the ratio, as can be seen in Fig 1. Measurement of both right and left hands were measured twice. The functions (zoom-in, zoom-out, and image enlargement) in the software enabled the researcher to accurately measure from the crease at bottom of finger to tip for both index and ring finger.

The aforementioned procedure was performed by a trained researcher to avoid intraobserver error. Interrelation coefficient (ICC) analysis was conducted earlier using a two-way mixed-effect model (Model 3) based on a single measure (Form 1), and the type of absolute agreement was selected. The result of the ICC (3,1) indicated high intraobserver reliability, with a score of 0.997, which was interpreted as an excellent inter-repeatability, and can be used for further analysis.

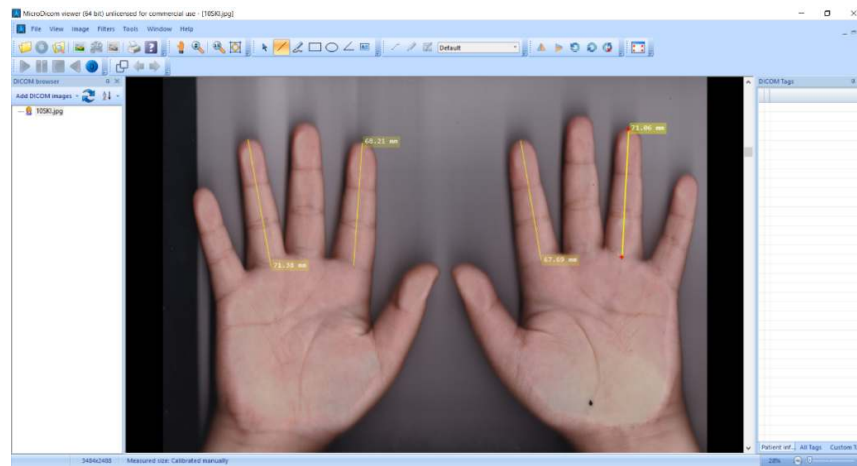


Fig 1. Measurement of the 2D:4D length using MicroDicom viewer

Statistical Analysis

Statistical analysis was conducted using the IBM SPSS Statistics software (version 26.0) to transform and evaluate the data. Normal distribution of the data was checked using the Shapiro–Wilk test in an earlier phase of data analysis, and the descriptive statistics of the mean and standard deviation was measured based on the 2D:4D measurement among the rugby and non-athlete groups. As for the inferential analysis, the data of the both groups were compared using independent samples *t*-test.

Results

Table 1 presents the output data that consisted of 76 male participants from U20 male rugby sevens athletes ($n=36$) and non-athletes ($n = 40$). For the male rugby sevens players, the mean and standard deviation for age were 18.61 ± 0.77 years, whereas for non-athletes, they were 18.73 ± 0.75 years. The 2D:4D ratios of both hands (RL 2D:4D) were lower in the rugby group ($M \pm SD = 0.943 \pm 0.034$ mm) than in the non-athlete group ($M \pm SD = 0.993 \pm 0.034$ mm). The same trend was observed for both low and high 2D:4D with rugby group demonstrated lower 2D:4D at low 2D:4D ($M \pm SD = 0.938 \pm 0.026$ mm) and high 2D:4D ($M \pm SD = 1.033 \pm 0.002$ mm). Contrarily, the non-athlete group had higher reading at both the low ($M \pm SD = 0.976 \pm 0.019$ mm) and high ($M \pm SD = 1.038 \pm 0.016$ mm) 2D:4D. Furthermore, high number of participants in category low 2D:4D was detected in rugby group with 34 players categorized as low 2D:4D (94.44%) and only 2 players categorized as high 2D:4D (5.55%). Meanwhile, in the non-athlete group, category high 2D:4D was more visible with 11 participants recorded to possessed high 2D:4D (27.50%) and the rest of 29 participants were categorized as low 2D:4D (72.50%).

Table 1. 2D:4D description of the male groups

Group		n	Min	Max	Mean	SD
Rugby (n = 36)	Age (years)	36	18	20	18.61	0.77
	RL 2D:4D (mm)	36	0.890	1.034	0.943	0.034
	Low 2D:4D (mm)	34	0.890	0.990	0.938	0.026
	High 2D:4D (mm)	2	1.031	1.034	1.033	0.002
Non-athlete (n = 40)	Age (years)	40	18	20	18.73	0.75
	RL 2D:4D (mm)	40	0.943	1.069	0.993	0.034
	Low 2D:4D (mm)	29	0.943	0.998	0.976	0.019
	High 2D:4D (mm)	11	1.026	1.069	1.038	0.016

Table 2 presents the the description of 76 U20 female rugby sevens athletes (n = 36) and non-athletes (n = 40). For female rugby sevens players, the mean and standard deviation for age were 18.64 ± 0.76 years, whereas for non-athletes, they were 19.03 ± 0.70 years. As for RL 2D:4D, the result indicated that the 2D:4D were lower in the rugby group ($M \pm SD = 0.967 \pm 0.039$ mm) than in the non-athlete group ($M \pm SD = 1.020 \pm 0.032$ mm) that can be averagely counted as high 2D:4D. The same pattern was observed in female groups, with the rugby group demonstrating lower 2D:4D at low 2D:4D ($M \pm SD = 0.953 \pm 0.023$ mm) and high 2D:4D ($M \pm SD = 1.037 \pm 0.022$ mm). On the other hand, the non-athlete group exhibited higher reading at both low ($M \pm SD = 0.980 \pm 0.018$ mm) and high ($M \pm SD = 1.040 \pm 0.013$ mm) 2D:4D. In addition, high number of participants in category low 2D:4D was found in rugby group with majority 30 players categorized as low 2D:4D (83.33%) and only 6 players categorized as high 2D:4D (16.66%). Meanwhile, in the non-athlete group, category high 2D:4D was more visible, with 27 participants recorded to have high 2D:4D (67.50%) and the remaining 29 participants recorded to have low 2D:4D (32.50%).

Table 2. 2D:4D description of the female groups

		n	min	max	m	sd
Rugby (n = 36)	Age (years)	36	18	20	18.64	0.76
	RL 2D:4D (mm)	36	0.910	1.070	0.967	0.039
	Low 2D:4D (mm)	30	0.910	0.990	0.953	0.023
	High 2D:4D (mm)	6	1.012	1.070	1.037	0.022
Non-athlete (n = 40)	Age (years)	40	18	20	19.03	0.70
	RL 2D:4D (mm)	40	0.943	1.058	1.020	0.032
	Low 2D:4D (mm)	13	0.943	0.998	0.980	0.018
	High 2D:4D (mm)	27	1.012	1.058	1.040	0.013

The results of the 2D:4D description of both genders indicated that both genders in the rugby group exhibited much lower 2D:4D than their counterpart (non-athlete group). Moreover, participants with low 2D:4D were also high in number especially for both male and female rugby group compared with non-athletes that conversely demonstrated higher prevalence of high 2D:4D participants.

Table 3. Comparison of the 2D:4D ratios of the male groups

Male	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	95% C.I	
							Lower	Upper
RL 2D:4D	0.744	-6.422	74	0.000	-0.050	0.008	-0.065	-0.034
		-6.421	73.10	0.000	-0.050	0.008	-0.065	-0.034

* $p < 0.05$

Table 3 presents the results of the comparison of the 2D:4D ratios on both hands between the rugby and non-athlete groups, which indicated a significant effect on RL 2D:4D, $t(74) = -6.422$, $P = .000$, with the rugby group ($M \pm SD = 0.943 \pm 0.034$ mm) obtaining higher scores than the non-athlete group ($M \pm SD = 0.993 \pm 0.034$ mm). This suggested that the rugby group possessed a much lower 2D:4D, thus exhibiting high prenatal testosterone among them compared with the non-athlete group.

Table 4. Comparison of the 2D:4D ratios of the female groups

Female	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	95% C.I	
							Lower	Upper
RL 2D:4D	0.681	-6.553	74	0.000	-0.053	0.008	-0.069	-0.037
		-6.486	67.96	0.000	-0.053	0.008	-0.069	-0.037

* $p < 0.05$

Meanwhile, as can be seen from Table 4, the results of the comparison of the 2D:4D ratios on both hands between the rugby and non-athlete groups indicated that there was significant effect on RL 2D:4D, $t(74) = -6.553$, $P = .000$, with the rugby group ($M \pm SD = 0.967 \pm 0.039$ mm) obtaining higher scores than the non-athlete group ($M \pm SD = 1.020 \pm 0.032$ mm). This suggested that the rugby group had a much lower 2D:4D ratio, thus exhibiting high prenatal testosterone among them. As for the non-athlete group, majority of the female participants had high 2D:4D.

Discussion

This study aimed to detect 2D:4D disparities between the rugby group and the non-athlete group and to establish the general 2D:4D status of rugby sevens players, in particular. The result of this study is in agreement with that of the research by Azam et al. (2019) and Bennett et al. (2010), who found that low 2D:4D was more prevalent among both genders in the rugby group than the non-athlete group. Furthermore, male rugby players accounted for 94.44% with low 2D:4D, whereas female rugby players accounted for 83.33%. This suggested that individuals with high testosterone levels dominated the rugby group, a finding consistent with that of Kim and Kim's (2016) review on the relationship between 2D:4D and sports performance. Previous research by Manning and Taylor (2001) also demonstrated that in the English football league, the majority of the first 11 football players had lower 2D:4D than the substitute players. Meanwhile, in Greco-Roman wrestling, world-class wrestlers were classified from non-elite wrestlers using a 2D:4D classification (Keshavarz et al., 2017). Therefore, it can be suggested that status low and high 2D:4D has the ability to represent engagement in sport and achievement status in sport.

Concurrently, there was a negative association between 2D:4D and good physical performance for Olympic female players, as investigated by Eklund et al. (2020), and fencing, as explored by Voracek et al., (2010), because most female athletes with low 2D:4D had high attainment level in sports. The same was observed in this study, which found that the rugby group of both genders had substantial disparities on 2D:4D when compared with the non-athlete group. Thus, it has been suggested that sports participants are often dominated by individuals with higher testosterone levels. Furthermore, the descriptive analysis of the 2D:4D ratio among male and female rugby players revealed that those with low 2D:4D outnumbered those with high 2D:4D. Participation of low 2D:4D females in highly aggressive competitive rugby sevens is in adjunct with past studies mentioning low 2D:4D to be strongly linked with aggressive and assertive behavioral traits in both males and females (Adamczyk et al., 2021; Breedlove, 2010; Reed et al., 2017). Looking into rugby sevens as a high-risk sport and frequently played with a high degree of aggressiveness; it is generally classified as a "male" activity; however, when associating 2D:4D with sports participation, the fact still remains the same, with females who have participated in rugby sports reported having low 2D:4D.

In another influential study, Bennett et al. (2010) claimed that an individual with a high level of testosterone has a high level of rugby engagement, especially among elite players who have lower 2D:4D than non-elite players. Reflecting on a study conducted by Reed et al. (2017) regarding athletes of contact sports, including boxing, rugby, and football, and non-contact sports, such as badminton, basketball, and golf, Reed were able to demonstrate that the contact sports had much lower 2D:4D than the non-contact sports. This is most likely related to the elevated exposure of testosterone levels, which causes a proclivity to engage in aggressive sports. Previously, evidence from the study by Ribeiro et al. (2016) pointed out that a high prenatal testosterone level reflects better capability to perform in strength-based events, which can be linked to the high physical strength required in rugby sports. Rugby requires players to demonstrate a high level of efficiency in performing various biomotor abilities, such as cardiovascular endurance, muscular endurance, power, speed, agility, and strength, indicating that high testosterone levels or low 2D:4D ratios can support the strength of these fitness components. In that case, low 2D:4D has been negatively correlated with good performances in various physical fitness testing, as reviewed by Pasanen et al. (2021). This also has been reported in various studies, with most of them being able to discover a reliable association between low 2D:4D and achieving good scores in physical fitness testing on both genders (Hönekopp and Schuster, 2010; Kozziel et al., 2017; Paul et al., 2006; Ranson et al., 2015). As a result, low 2D:4D is a highly likely hereditary trait that can contribute to high levels of performance in exercise testing or sports, particularly in rugby.

Conclusions

Based on the results, it is safe to suggest that 2D:4D is negatively correlated with the level of testosterone, as observed in other related studies. In general, males have lower 2D:4D than females because the males tend to have high prenatal testosterone levels than females, which is common in previous studies. As can be seen in this study, the results demonstrated that majority of the female rugby players were more bias to lower 2D:4D than high 2D:4D, indicating that females who participate in this masculine sport have high prenatal testosterone levels. Therefore, the role of testosterone in affecting the aggressiveness of the player is not limited to male gender only; it is also true in both genders and is evident in most sports requiring aggressiveness. This is possible due to the effect of testosterone in aiding the physiology and muscle development growth.

Furthermore, majority of the male and female rugby players had low 2D:4D resulting in significant difference in between both genders in the rugby group compared with the non-athlete group. As a result, this study backs up previous findings that linked low 2D:4D to high-risk and aggressive sports, particularly rugby in both genders. It is highly likely that prenatal testosterone plays an important role in the organizational pathway on the 2D:4D development and also affects the physiological development of the body. This study managed to include a substantial number of players; however, it is recommended to include both genders and a much higher number of athletes as well as to incorporate a variety of sports in future studies so that a better perspective regarding the role of 2D:4D in variety of sports across genders can be obtained.

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Conflicts of interest - The authors report no conflict of interest.

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