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Can Our Fingers Alone Raise Us Up to the Sky? Analysis of the Digit Ratio Association with Success in Olympic Wrestling

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ABSTRACT

The aim of this study is to analyse the contribution of the second to fourth digit ratio (2D:4D) to success in wrestling. A total of 180 elite wrestlers who participated in the 2011 Spanish Wrestling Championship took part in this study (132 men, 23.6±6.1 years old; 48 women, 21.7±4.9 years old). Prior to competition, wrestlers were interviewed about their years of training experience and their hands were scanned. 2D:4D was calculated using computer-assisted image analysis. A multinomial logistic regression coefficient to calculate odd ratios (OR's) and 95% confidence intervals (CI's) were established to determine the contribution of digit ratio and training experience to success in Olympic wrestling. Additionally, mean and median analyses were calculated between males and females, and between successful and non-successful wrestlers in order to establish differences in 2D:4D and training experience between these groups. There were no differences between successful and non-successful wrestlers in 2D:4D (p=0.87 for right hand, and p=0.46 for left hand), whereas having high training experience supposed an increase up to 4.38 (1.70–11.01) times more likely to be successful. Our results suggest that 2D:4D fails in predicting wrestling success, whereas training background is a good predictor of competition prowess in highly trained wrestlers.

Key words: *kinanthropometry, performance predictor, 2D:4D, combat sport, training experience*

Introduction

The second-to-fourth digit ratio (2D:4D) has been reported to be negatively correlated with sport performance in male and female athletes across a variety of sports[1], even when physical factors and effort, cognitive, and personality variables are controlled[2].

Lower 2D:4D has been correlated with higher sport performance in endurance events such as middle-distance running[3] or rowing[4], in team sports such as soccer[3] or rugby[5], or even in sports with great ability and technical requirements such as skiing[6] or fencing[7,8], mainly associated with the differences in the athletes´ prenatal androgen exposure.

Male and female Olympic wrestling has recently been described as an intermittent physical combat sport, which requires huge psychological demands, a great physical fitness level as well as an optimal body composition, to achieve international participations in major tournaments[9,10]. Other recent researchers have not identified any basic anthropometrical marker (i.e., height, arm span and sitting height) that can differentiate competitive levels in wrestling[11]. Conversely, to the authors´ knowledge, no previous studies have investigated the relationship between 2D:4D and the sport performance in any combat sport such us judo, boxing, taekwondo or wrestling. If this relationship exists, then this reliable and relatively easy anthropometrical assessment could be of great interest for coaches and sport scientists to optimize talent selection.

Therefore, the aim of this study was to examine the validity of the 2D:4D method in predicting the competitive level in Olympic wrestling, a combat sport that combines a great amount of psychological, technical, anthropometrical and physical fitness requirements. Based on the aforementioned studies, we hypothesized that digit ratio could differentiate successful and non-successful highly trained wrestlers.

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Materials and Methods

Subjects

A total of 180 wrestlers that took part in the 2011 Spanish Wrestling Championship, in one of the three Olympic wrestling styles, participated in the study: Greco-Roman Male (GRM), N=60; Freestyle Male (FSM), N=72; and Freestyle Female (FSF), N=48. The tournament was formally refereed and scored according to the International Federation of Associated Wrestling Styles' (FILA) official regulations. The results of this competition were used by the national selectors to choose the Spanish team members for an upcoming international tournament.

According to the tournament results, two different competitive levels (i.e., successful and non-successful) were established in each wrestling style and weight category for subsequent comparisons. Successful groups of wrestlers were formed from the four medal winners (i.e., 1st, 2nd, and the two 3rd classified) in each of the 7 weight categories for both male styles (i.e., GRM and FSM: <55 kg, <60 kg, <66 kg, <74 kg, <84 kg, <96 kg, >120 kg) and the 7 weight categories for the female style (i.e, FSF: <48 kg, <51 kg, <55 kg, <59 kg, <63 kg, <67 kg, >72 kg). A detailed summary of participants' physical characteristics is shown in Table 1 (Table 1).

Prior to weighing for official categorization and 24 hours before the competition, participants were interviewed about their years of training and competition experience in wrestling. They were also asked to remove rings or other elements that would interfere with obtaining finger length measurements. Then, participants placed both hands onto a digital scanner (Canon Lide 110 Tokyo, Japan), with their palms down, and an image, with 300 dpi resolution, was taken. Digit Ratios were established using a computer-assisted image analysis (GNU Image Manipulation Program, GIMP, Version 2.217). 2D:4D determined from computer-assisted analysis has shown the most accurate and consistent measurements among observers[12]. All digits were measured from the proximal basal crease of the digit to the tip by a single expert in ISAK (International Society for the Advancement of Kinanthropometry) and other anthropometric protocols. By using codes to identify each participant, the observer was unaware of the wrestlers' weight category or competition level. 2D:4D ratio was calculated separately for each hand and each digit length. All measurements were taken two non-consecutive times, with the median of the two measurements considered for subsequent analysis.

TABLE 1
DESCRIPTIVE CHARACTERISTICS OF THE SUBJECTS

	Greco-Roman Male (N=60)	Freestyle Male (N=72)	Freestyle Female (N=48)
Weight (kg)	78.8±18.9	75.4±15.4	57.9±7.7
Height (cm)	174.4±7.7	173.7±7.3	161.3±5.2
Age (years)	24.2±7.1	23.3±5.0	21.7±4.9

TABLE 2
VALUE RANGE OF THE 2D:4D AND YEAR RANGE OF EXPERIENCE ESTABLISHED ACCORDING TO PERCENTILES (25, 50, 75) OF EACH WRESTLING STYLE

	Greco-Roman Male (N=60)	Freestyle Male (N=72)	Freestyle Female (N=48)
2D:4D – Right Hand		N for each level and range (Min. – Max.)	
Low	15 (0.893 – 0.943)	21 (0.887 – 0.934)	13 (0.902 – 0.945)
Medium - Low	15 (0.945 – 0.959)	15 (0.943 – 0.953)	11 (0.946 – 0.976)
Medium - High	15 (0.960 – 0.979)	19 (0.954 – 0.973)	13 (0.979 – 0.998)
High	15 (0.981 – 1.052)	17 (0.980 – 1.029)	11 (1.000 – 1.063)
2D:4D – Left hand			
Low	15 (0.898 – 0.936)	18 (0.887 – 0.930)	12 (0.894 – 0.947)
Medium - Low	15 (0.937 – 0.957)	19 (0.931 – 0.950)	12 (0.950 – 0.969)
Medium - High	15 (0.958 – 0.976)	17 (0.952 – 0.979)	12 (0.970 – 0.990)
High	15 (0.978 – 1.046)	18 (0.981 – 1.083)	12 (0.992 – 1.037)
Training experience (years)		N for each level and range (Min. – Max.)	
Low experience	17 (1 – 6)	18 (1 – 3)	13 (1 – 3)
Medium – Low experience	22 (7 – 10)	20 (4 – 6)	14 (4 – 6)
Medium – High experience	6 (11 – 12)	16 (7 – 12)	10 (7 – 9)
High experience	15 (14 – 32)	18 (13 – 21)	11 (10 – 34)

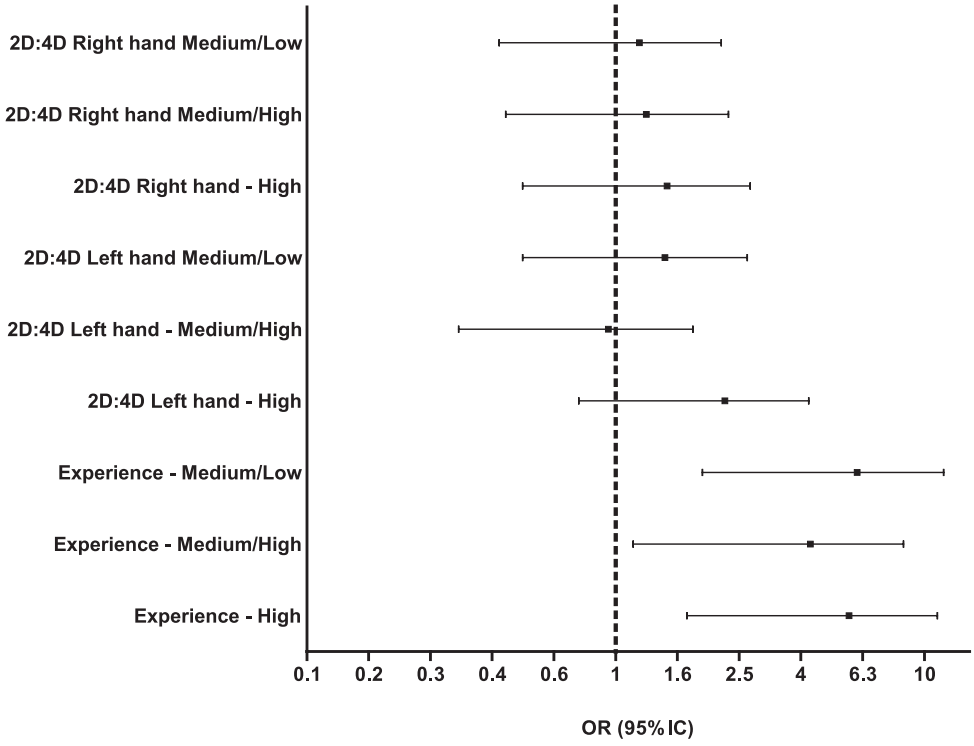

Fig. 1. Multinomial logistic regression model examining total sample championship success as a function of 2D:4D and as a function of experience.

Statistics

The Kolmogorov-Smirnov test and complementary analyses of normality were used to determine if training experience and 2D:4D were normally distributed. Then, a t-test was performed to establish *2D:4D* differences, and a Wilcoxon-Mann-Whitney test was carried out to establish the differences in years of training experience between successful and non-successful participants in each wrestling style. A correlation analysis between measurement values and between hands was performed to elicit the expected inter-measures and hands concordance. In the same way, sex differences in 2D:4D were established through an independent samples t-test. To avoid expected sex differences, 2D:4D measures were standardised, converting them into z-scores before performing t-test in the total sample.

After data acquisition, we established a value range of digit ratios and wrestling experience by the following procedure: wrestlers were grouped into proportional size groups prior to statistical analyses with three cut off points (percentiles 25, 50 and 75) relative to their own wrestling style. Then, we used a multinomial logistic regression analysis to model the association between these

TABLE 3
ANALYSIS OF DIFFERENCES BETWEEN SUCCESSFUL AND NON-SUCCESSFUL WRESTLERS IN SECOND TO FOURTH DIGIT RATIO (T-TEST)

	2D:4D – Right hand				2D:4D – Left hand			
	Successful	Non-successful	T	p	Successful	Non-successful	t	p
Greco-roman Male	0.96 ± 0.03	0.96 ± 0.03	0.42	0.67	0.96 ± 0.03	0.96 ± 0.03	-0.06	0.97
Freestyle Male	0.96 ± 0.03	0.96 ± 0.03	0.22	0.98	0.95 ± 0.04	0.95 ± 0.03	0.15	0.89
Freestyle Female	0.97 ± 0.03	0.98 ±0.04	-0.79	0.43	0.97 ± 0.03	0.97 ± 0.03	0.43	0.67
All*	0.96 ± 0.03	0.96 ± 0.03	0.16	0.87	0.96 ± 0.04	0.96 ± 0.03	0.74	0.46

*Standardised (z-scores) prior t-test analysis in total sample to avoid observed sex differences in digit ratio. Means and standard deviation presented are descriptive of non-standardised values in total sample

groups and championship prowess, calculating the odds ratio (OR) and confidence interval 95% (CI). Statistical treatment of the data was performed using the program package SPSS 15.0 for Windows.

Results

Table 2 shows the value range of selected variables according to the wrestlers' style and the groups' distribution for multinomial logistic regression analysis. Prior to 2D:4D comparisons between successful and non-successful wrestlers, reliability was established through a strong correlation between the two measurements taken ($r \geq 0.95$). Although, a correlation analysis of the means of right and left hand 2D:4D showed a significant and positive correlation in all wrestling groups (male $r=50.66$, $p<0.001$; female $r=50.48$, $p<0.05$) (Table 2).

We found differences between sexes and we could determine that 2D:4D was greater in men than women in both hands (right hand t-test $p=0.009$, $t=-2.63$; left hand t-test $p=0.015$, $t=-2.45$). However we could not find 2D:4D association with success in the total sample population or in any wrestling style (Table 3). No statistical differences were detected in 2D:4D between successful and non-successful wrestlers, neither t-test nor multinomial logistic regression analysis (Figure 1 and Table 3).

Figure 2 shows the differences in years of experience between successful and non-successful participants in each wrestling style. Training experience was statistically related with success: using median analysis we found differences in two of the three groups studied, Female Freestyle and Greco-Roman style. In the total sample, experience was related with success as shown in Figure 1 using multinomial logistic regression analysis (Figure 2).

Discussion and Conclusion

The main finding of the present study was that 2D:4D is not a valid assessment to discriminate successful and non-successful wrestlers, while training experience is a good predictor of competition prowess in that kind of highly trained athletes.

Despite the emergence in the last years of a growing field of studies centred on the importance of 2D:4D in sport talent identification, as described for soccer, skiing, running, rugby, fencing or rowing[1,3-5,7], this study shows that 2D:4D itself, fails in predicting competition prowess in highly trained wrestlers.

As a possible marker of prenatal testosterone exposure (which could be a key factor in strength development), 2D:4D has been proposed as an indirect measure which can discriminate an exceptional and talented genotype for sport participation[1]. However, the use of this anthropometric index in predicting athletic prowess presents some problems: first, the heterogeneity of assessment methods and the measurement processes (from radiological to direct measurement, image scanning or photocopy analysis of finger lengths) which sometimes are inaccurate, inconsistent and unreliable (when direct measurements are used, researchers need a huge amount of experience in the measurement processes)[12]. In this sense and as said before, finger length measurement through computer-assisted image analysis, as used in this study, yields the most accurate and consistent measurements[12], but most of the cited studies have not used this method. Second, validity of 2D:4D as a testosterone marker is questioned by some authors, and it has been defined that it is not a good marker of individual differences in prenatal androgen exposure[13-15], while other researchers have concluded that the relationships of the 2D:4D ratio with sex steroids in athletes is very moderate[16]. Also, it has been described that 2D:4D varies over time and could be influenced by external factors, for example, selective breeding for increased rates of voluntary exercise in rodents can modify finger length ratios[17]. Third, 2D:4D could be related with general musculoskeletal and cardiovascular fitness, as described in task outcomes with poor perceptive and decision-making demands[18], but visual-spatial abilities are not related with 2D:4D[19]. These facts, in our opinion, could underscore the validity of 2D:4D method as a determinant factor of prowess in a great number of sport modalities.

2D:4D studies in sport try to reopen the long nature versus nurture debate, the concern to the relative importance of an athlete's innate qualities versus his personal experiences in determining individual differences in physical and behavioural traits. It has been described that, when comparing with the non-sporty population, elite athletes have different biological characteristics that could lead to a better training adaptation[20]. But many studies describing physiological and genetic characteristics of elite athletic groups have shown us that elite peers do not differ a lot in their genetic characteristics[21,22]. However, an adequate training periodization and peaking process, as well as training and competition background, have been shown to be the major differences between successful and non successful elite athletes [21]. We have defined previously in another study that a combination of training experience, muscle power output and maximum strength explains the

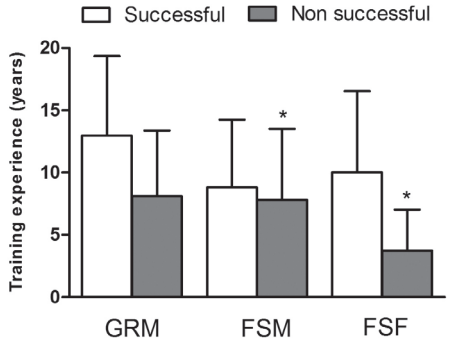

*Fig. 2. *p<0.05 Importance of expertise on competition success (years of previous wrestling training for each group and modality, wilcoxon-mann-whitney test). GRM: Greco-roman Male; FSM: Freestyle Male; FSF: Freestyle Female.*

89.1% of success in highly trained wrestlers[11], and the training experience alone was the most important prowess predictor, explaining the 76.1% of success probability. Nevertheless, a meta-analysis of twenty five 2D:4D studies show that this anthropometric measure counts only for between 1%–16% of the variance in sport prowess, depending on the cited study[23].

This work focuses the importance of training experience between elite athletes and provides a critical insight into the background knowledge of the 2D:4D importance in the field of talent identification and development in sport sciences. We believe that sport success is a complex phenomenon, in which a single anthropometric measure should not be proposed as a major factor of this success. Talent in combat sports could be formed by a combination of heterogeneous characteristics, which require and are mediated by a long learning and training process.

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MOŽEMO LI SE SAMO PRSTIMA PODIĆI DO NEBA? ANALIZA KORELACIJE OMJERA PRSTIJU S USPJEHOM U OLIMPIJSKOM HRVANJU

SAŽETAK

Cilj ovog rada je bio analizirati doprinos omjera drugog i četvrtog prsta (2D: 4D) s uspjehom u hrvanju. Ukupno 180 elitnih hrvača koji su sudjelovali u španjolskom prvenstvu u hrvanju 2011. godine su sudjelovali u ovom istraživanju (132 muškaraca, 23,6 ± 6,1 godina star, 48 žena, 21,7 ± 4,9 godina). Prije natjecanja, hrvači su intervjuirani o svojim godinama iskustva treniranja i njihove ruke su skenirane. Omjer 2D: 4D je izračunat pomoću računala kroz analizu slike. Uspostavljeni su multinomni koeficijenti logističke regresije za izračunavanje omjera izgleda (OR) i 95% pouzdanosti intervala (CI-a) za određivanje doprinosa omjera prstiju i godina iskustva u treniranju prilikom uspjeha u olimpijskom hrvanju. Osim toga, izračunate su srednje vrijednosti i medijani analize između muškaraca i žena i između uspješnih i neuspješnih hrvača kako bi se utvrdile razlike u omjeru 2D: 4D kao i iskustva treniranja između ovih skupina. Nije bilo razlike između uspješnih i ne-uspješnih hrvača u omjeru 2D: 4D (p=0,87 za desnu ruku, p = 0,46 za lijevu ruku), dok je visoko iskustvo treninga dovelo do povećanja od 4,38 (1,70 – 11,01) puta više vjerojatnosti da će biti uspješni. Naši rezultati ukazuju na to da omjer 2D: 4D ne pomaže u predviđanju uspjeha u hrvanju, dok je povijest treniranja dobar pokazatelj uspješnosti u natjecanjima kod profesionalnih hrvača.