

A Study of the Second Digit to Forth Digit Ratio targeting Taekwondo Athletes

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Abstract

Background/Objectives: The Second Digit (2D) to Forth Digit (4D) ratio is widely used as an indirect biological indicator that represents the prenatal sex hormone environment. This study was conducted to identify the relationships between the 2D:4D ratio and sexual dimorphism, BMI, exercise capacity and handedness targeting taekwondo athletes. **Methods/Statistical Analysis:** Data was collected using a self-report questionnaire and the scanning of both hands from July to October 2015, targeting a total of 224 taekwondo athletes including 84 national team athletes (51 males and 33 females) and 140 collegiate athletes (100 males and 40 females). The self-report questionnaire was composed of items necessary for measurement of BMI and exercise capacity such as gender, age, height, weight, type of handedness, award-winning experience, etc. **Findings:** As a result, the 2D:4D ratio of left-handedness showed a statistically significant difference in sexual dimorphism and the 2D:4D ratio between left-handedness and right-handedness showed a statistically significant correlation for both males and females. However, there was not a statistically significant correlation between the 2D:4D ratio and BMI index in left-handedness and right-handedness for both males and females. **Application/Improvements:** The findings of this study are meaningful in that they can be used as basic data necessary to find and nurture talented students with excellent qualities for becoming a taekwondo athlete.

Keywords: Correlation, Digit Ratio, Sexual Dimorphism, Statistical Analysis, Taekwondo

1. Introduction

The factors affecting the athletic performance of athletes vary including physiological variables. It is known that, where gender difference is taken into account, females have more advantageous physical qualities than males in enhancing athletic performance, because the patterns of testosterone secretion in the perinatal period and adulthood exert a significant influence¹. In other words, the intrauterine environment to which a fetus is exposed inside the mother's womb affects physiological aspects continuously after birth², thus having a relationship with not only human body composition³ but also the components of physical fitness such as muscular strength, speed, exercise capacity, etc⁴.

Since the relative levels of sex hormones such as testosterone and estrogen of prenatal environment affects the growth of the digits of a fetus, the 2D:4D ratio is widely

used as an indirect biological indicator that represents the prenatal sex hormone environment. It is known that the 2D:4D ratio is determined in the sensitive period of early development when the prenatal brain develops rapidly and after that, even if there are changes in digit length, the patterns of digits are not affected by testosterone circulating inside a body and by other factors⁵.

Further, reference⁶ proved that a low 2D:4D ratio has a statistically significant relationship with a high ratio of testosterone and estrogen measured in amniotic fluid. Likewise, the 2D:4D ratio is determined by a relative level of testosterone, the main male hormone and estrogen, the main female hormone to which a fetus inside the mother's womb is exposed and this is related to exercise capacity. Thus, the lower the 2D:4D ratio was, the higher exercise capacity was shown.

Specifically, according to reference⁷, professional soccer players show a low 2D:4D ratio compared to

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ordinary people and English Premier League's soccer players manifest a 2D:4D ratio lower than lower league soccer players. These phenomena also occurred among fencing⁸, rugby⁹ and American football¹⁰ players.

In addition, in the cases of the comparison of elite athletes and ordinary people¹¹ and the comparison of athletes in an elite athlete group according to exercise capacity¹², elite athletes showed a lower 2D:4D ratio than ordinary people and the higher the exercise capacity of elite athletes was, the lower their 2D:4D ratios were revealed.

The 2D:4D ratio is one of the typical indicators that represent sexually dimorphic traits, and generally, in males, an index finger is shorter than a ring finger ($2D:4D < 1$) and in females, an index finger is the same as or longer than a ring finger ($2D:4D \geq 1$). An experimental study using animals also proved that the 2D:4D digit ratio reveals sexual dimorphism and has a relationship with a certain behavior such as exercise capacity^{13, 14}, but some recent studies showed that the 2D:4D ratio has no relationship with testosterone exposure¹⁵.

However, a lot more study findings have shown that the 2D:4D ratio is significant as an indirect biological indicator that represents the prenatal testosterone level and is related to human body size, grip strength and physical fitness. Nevertheless, it is significant to conduct an additional study using an empirical data analysis to prove that the 2D:4D digit ratio reveals sexual dimorphism and has a relationship with a certain behavior such as exercise capacity. Although it is highly significant to conduct a study targeting athletes in taekwondo, a Korean national sport, little has yet been done in investigating taekwondo athletes.

This study intends to identify the relationships of the 2D:4D ratio with sexual dimorphism, BMI, exercise capacity and handedness targeting both the national team members nurtured as elite taekwondo athletes and general collegiate taekwondo athletes.

According to reference¹⁶'s study on the comparison of basal physical fitness and exercise capacity between male collegiate taekwondo athletes and national taekwondo team athletes, the basal physical fitness, muscular strength, etc. of the latter were statistically significantly higher compared to the former. So, this study intends to identify the relationships between the 2D:4D ratio and exercise capacity, etc. to provide basic data necessary to find and nurture talented students with excellent qualities to become a taekwondo athlete.

2. Research Method

2.1 Data Collection

The main purpose of this study is to review the matters related to personal traits such as sexual dimorphism, BMI and exercise capacity from a statistical perspective using the 2D:4D ratio of taekwondo athletes. To this end, data was collected using a self-report questionnaire and the scanning of both hands from July to October 2015, targeting a total of 224 taekwondo athletes including 84 national team athletes (51 males and 33 females) and 140 collegiate athletes (100 males and 40 females). The self-report questionnaire was composed of items necessary for measurement of BMI and exercise capacity such as gender, age, height, weight, type of handedness, award-winning experience, etc.

2.2 Digit Ratio Measurement

As shown in Figure 1, the length of fingers was measured using a digital scanner after marking the creases of an index finger and a ring finger near to the palm¹⁷. After that, they were measured to an accuracy of 0.1 mm using a vernier caliper. The measurement was carried out by the researcher of this study two times and the average of the two measurements was decided as the finger length.

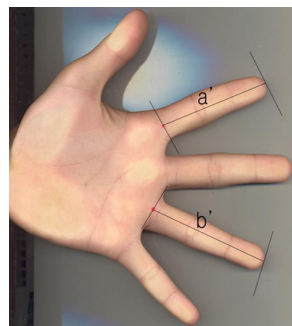


Figure 1. Measurement using calliper after scan.

2.3 Measurement of Exercise Capacity

To identify the relationships between the 2D:4D ratio and exercise capacity in taekwondo athletes, it is necessary to quantify the exercise capacity of participants. Exercise capacity was operationally defined as the points gained from award-winning experiences and the criteria for quantifying award-winning experiences were established as shown in Table 1. All award-winning experiences were made to be measurable by allowing respondents to multiple responses in the process of receiving responses.

Table 1. Criteria for quantifying award-winning experiences

Classification	1st place (gold medal)	2nd place (silver medal)	3rd place (bronze medal)
National Sports Competition	20 points	10 points	5 points
Universiade	30 points	20 points	10 points
Asian Game	30 points	20 points	10 points
World Championships	50 points	30 points	20 points
Olympics	100 points	70 points	50 points
Other nationwide competition	10 points	7 points	5 points

2.4 Analysis Methods

The 2D:4D ratio of respondents and the overall features of demographic matters were identified using descriptive statistics. Next, whether there was any statistically significant difference between the two groups according to sexual dimorphism and handedness was identified using statistical analysis methods such as an independent two sample t-test. Further, the relationship between the 2D:4D ratio and exercise capacity was identified using a correlation analysis.

3. Statistical Analysis

3.1 Descriptive Statistics

The male ratio was higher than the female ratio with 67.4% and 32.5% respectively and the ratio of right-handedness was overwhelmingly high. BMI index, which represents a measure to determine obesity, turned out to be normal for both males and females.

Table 2. Descriptive statistics

variable	attribute	count(%) / m(sd)
gender	male	151(67.4%)
	female	73(32.6%)
usual use hand	right hand	204(91.5%)
	left hand	19(8.5%)
height	male	180.3(5.95)
	female	168.0(6.62)
weight	male	72.5(10.33)
	female	60.4(8.68)
age	male	20.3(1.98)
	female	19.1(1.97)
BMI	male	22.2(2.30)
	female	21.3(2.58)

3.2 Gender Differences in 2D:4D

An independent two sample t-test was conducted to identify whether sexual dimorphism in the 2D:4D ratio appeared in taekwondo athletes. In the right hand, 2D:4D ratios of females was slightly higher than those of males, but the difference was not statistically significant. In the left hand, 2D:4D ratios of males and females were 0.9437 and 0.9559 respectively, indicating ratio of female was high. So, as shown in Table 3, the difference between the two was statistically significant at a 5% significance level. Consequently, it can be said that a gender difference of 2D:4D ratio exists in taekwondo athletes.

Table 3. Gender differences in 2D:4D

	gender	mean	sd	t	p-value
right hand	male	0.9609	0.033	-1.012	0.312
	female	0.9659	0.038		
left hand	male	0.9437	0.034	-2.500	0.013
	female	0.9559	0.034		

3.3 Association with BMI index

A correlation analysis was conducted to identify the relationship between the 2D:4D ratio and BMI index of taekwondo athletes. As shown in Table 4, the relationship between the 2D:4D ratio and BMI index of the right hand and the left hand was not statistically significant for either males or females.

When these results were compared with the results of Stefan's (2009) study conducted targeting ordinary people aged 18 to 30, the results in males were not consistent but the results in females were consistent. It is found that although the average age of taekwondo athletes targeted by this study was around 20 and didn't represent taekwondo athletes of all ages, the relationship between the 2D:4D ratio and BMI index was not statistically significant for taekwondo athletes.

Table 4. Correlation coefficient with BMI index

	gender	correlation	p-value
right hand	male	-0.062	0.450
	female	-0.064	0.593
left hand	male	-0.037	0.648
	female	-0.033	0.783

As shown in Table 5 and Figure 2, females showed a slightly higher correlation than males in the 2D:4D ratios of the right hand and the left hand. However, it can be said that not only the case of females but also the case of males showed statistically significant results.

Table 5. Correlation coefficient between right and left hand ratio

gender	correlation	p-value
male	0.442	0.000
female	0.538	0.000

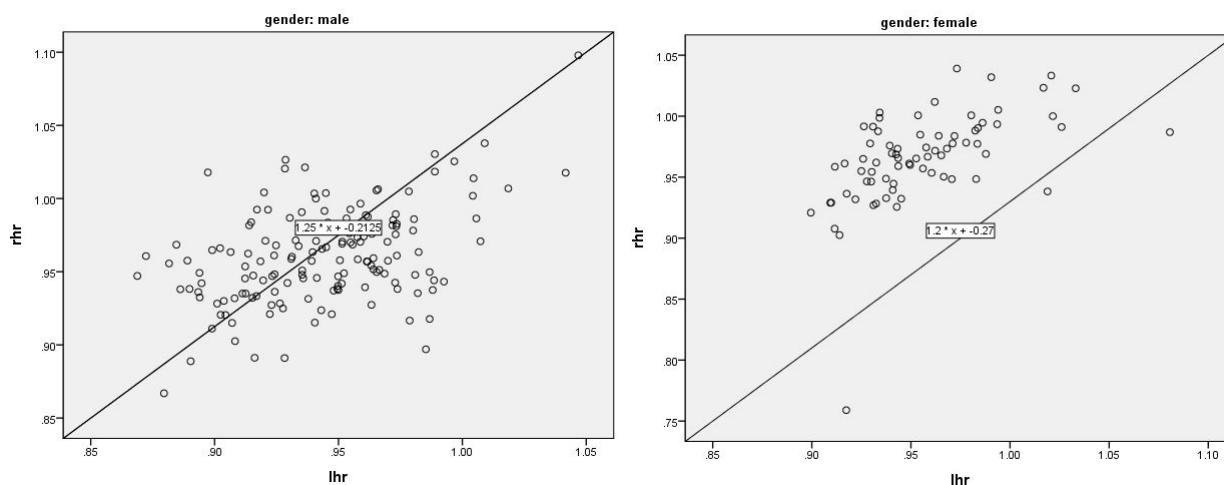
3.4 Relationship with Exercise Capacity

Reference⁷ stated that the components of physical fitness such as running speed were related to the ratio 2D:4D, Park (2010) stated that judo athletes with a lower 2D:4D ratio had a higher exercise capacity. As reviewed above, the 2D:4D ratio revealed a relationship with the exercise capacity of athletes, which was confirmed for taekwondo athletes. A correlation analysis was conducted by quantifying award-winning experiences as exercise capacity using Table 1.

As shown in Table 6, both males and females had a higher correlation with the 2D:4D ratio of the left hand than the right hand, all of which turned out to not be statistically significant. However, when males and females were not separated, the correlation coefficient of the 2D:4D ratio of the left hand and exercise capacity was 0.174, which turned out to be statistically significant (p-value = 0.009). Thus, it cannot be said that taekwondo athletes reveal no correlation between the 2D:4D ratio and exercise capacity.

Table 6. Relationship with exercise capacity and 2D:4D ratio

	gender	correlation	p-value
right hand	male	-0.003	0.967
	female	0.012	0.920
left hand	male	0.135	0.098
	female	0.160	0.177

**Figure 2.** Regression between right and left hand ratio.

3.5 Test according to Handedness

The number of left-handed people is not very high and thus a statistical test was conducted using a nonparametric method. In other words, as the results of a Mann–Whitney test, the 2D:4D ratios according to each handedness didn't show a statistically significant difference.

Table 7. Test according to handedness

2D:4D ratio	gender	Z	p-value
right hand	male	-1.193	0.233
	female	-1.340	0.180
left hand	male	-0.379	0.705
	female	-0.122	0.903

4. Conclusion

According to reference¹⁸, the 2D:4D ratio is greatly affected by the relative level of sex hormones to which a fetus is exposed inside the mother's womb. Recently, it has been revealed that this 2D:4D ratio demonstrates a relationship with a specific behavior such as exercise capacity. Thus, the 2D:4D ratio is being utilized as an useful indicator in the early selection of excellent athletes¹⁹.

This study was conducted to identify the relationships of the 2D:4D ratio with sexual dimorphism, BMI, exercise capacity and handedness targeting taekwondo athletes. The study findings are summed up as follows:

First, in the right hand, 2D:4D ratios of females was slightly higher than those of males, but the difference was not statistically significant. In the left hand, 2D:4D ratios of males and females were 0.9437 and 0.9559 respectively, indicating ratio of female was high. The difference

between the two was statistically significant at a 5% significance level.

Second, the correlation between the 2D:4D ratio and BMI index of taekwondo athletes was not statistically significant in either the right hand or the left hand and for either males or females.

Third, the 2D:4D ratios of the left hand and the right hand revealed a slightly higher correlation in females than males. Not only was this the case for females that revealed a correlation coefficient of 0.538 but it was also the case for males who revealed a correlation coefficient of 0.442, thus demonstrating statistically significant results.

Fourth, when males and females were not separated, the correlation coefficient of the 2D:4D ratio of the left hand and exercise capacity was 0.174, which turned out to be statistically significant (p -value = 0.009). Thus, it was found that taekwondo athletes also revealed a correlation between the 2D:4D ratio and exercise capacity. However, the 2D:4D ratios according to each handedness didn't show a statistically significant difference.

The findings of this study are meaningful in that they can be used as basic data necessary to find and nurture talented students with excellent qualities for becoming a taekwondo athlete.

5. References

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