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Original Research

Digit Ratio (2D:4D) and Performance of Chinese Elite Archers

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Abstract

Background: Previous studies have found a correlation between digit ratio (2D:4D) and performance in sporting events which require physical competence. Such correlation, however, has not been well studied in technique-oriented sports. This study explored the correlation between 2D:4D and sporting performance of Chinese elite archers. Also it provides some references for sports research in other fields. **Methods**: We conducted the study with 31 Chinese elite archers (15 males and 16 females) preparing for the 2020 Tokyo Olympic Games and collected their 2D:4D ratios by measuring their index and ring fingers. The study also asked them to take physical fitness tests including push-ups, decline sit-ups, half-squat and a 4000-meter run, and obtained their results in former ranking tournaments and Olympic elimination series. The study recorded every entry of data in a "mean $\pm$ standard deviation" (M $\pm$ SD) format and processed them in SPSS 24.0 to produce One-Way ANOVA and Pearson correlations. **Results**: Our study found no significant difference between varied sporting levels in the left 2D:4D, and between world-class and national-level archers in the right 2D:4D ($p > 0.05$), yet a significant one between left-right 2D:4D of world-class, national-level, and level-1 archers ($p < 0.01$). We also found no significant correlation between the left 2D:4D and specific physical fitness test results, and between those archers' results. Similarly, there was a significant negative correlation between the right 2D:4D and specific test results ($p < 0.05$), and a strong negative correlation between that and results of ranking tournaments ($p < 0.01$) and Olympic elimination series ($p < 0.01$). **Conclusions**: Chinese elite archers with lower right 2D:4D are of better physical fitness and enhanced sport performance. Hence, the right 2D:4D may act as a critical indicator in selecting excellent archers.

Keywords: archery; finger length ratio; performance; correlation; sports selection

1. Introduction

When selecting highly qualified athletes for a specific training program, the specific principles of this program should be observed and appropriate methods should be applied, such as in archery [1]. Chinese archery, although often considered one of the "potential strengths", has been at a disadvantage in this selection due to the lack of support from archery coaches in terms of valid measurement indicators [2].

The digit ratio (2D:4D) is known as a key parameter in the selection of highly qualified athletes [3] and refers to the ratio between the index finger, the second digit length (2D) and the ring finger, the fourth digit length (4D) [4]. This concept was first introduced by Baker in 1888 [5,6], confirming that the length of a person's fingers is usually determined in the 13th week of foetal development [7] and remains almost constant throughout life [8], and since then it has been widely studied in various fields. Furthermore, it represents foetal prenatal intrauterine testosterone levels, which have long-term effects on the cardiovascular, musculoskeletal and urogenital systems in humans. Over the past 20 years, it has been introduced into sports research with some success. Studies have demonstrated that elite athletes have lower 2D:4D than non-athletes, meaning that a person's athletic ability is negatively correlated with their 2D:4D ratio [9].

Furthermore, some studies have shown that the ratio of second to fourth digit length (2D:4D) is a correlate of prenatal testosterone whilst a high 2D:4D is associated with low prenatal testosterone [10]. A person's 2D:4D, physical fitness and athletic performance are correlated, as has been demonstrated in professional fencing [11], in addition to rugby [12], rowing [13], soccer [14], swimming [15] and basketball [16]. Later, other studies showed a strong correlation between 2D:4D and athletic performance, which was clearly demonstrated in medium-distance running (800–10,000 m) and less important in sprinting and ball sports [17]. However, these studies have focused on sporting events for athletes requiring physical ability, with little mention of the correlation between 2D:4D and athletic performance of elite archers in Olympic training programs.

Archery is composed of six phases: bow hold, drawing, full draw, aiming, release, and follow-through. From drawing to the release phase, an archer pushes the bow towards the target with one arm extended, while the other arm carries out a rhythmic and dynamic pulling of the bowstring [18]. In the period of anchor, the string fingers (index, middle and ring finger) play an important role in maintaining

stability, the possibility of slippage is reduced with a longer ring finger than the index finger, thereby contributing to the steady performance to an archer.

Therefore, we conducted the current study with 31 elite archers preparing for the 2020 Tokyo Olympic Games based on the hypothesis that archers of various levels would display significant 2D:4D differences, and the 2D:4D of elite archers may negatively correlate with their specific physical fitness and games results. By finding out morphological indices associated with elite archers' sporting performance, we intended to offer a proposal for better high-calibre archer selection.

2 Subjects and Methods

2.1 Subjects

We selected 31 archers, including 8 world-class (male = 4, female = 4), 15 national-level (male = 7, female = 8), and 8 level-1 players (male = 4, female = 4), who all performed in the second archery trial for the Tokyo 2020 Olympic Games.

All players were Han Chinese to exclude possible ethnic differences in 2D:4D, and they each gave informed consent. In addition, we likewise obtained informed consent from the guardians of minor archery athletes under the age of 18 years. Ethical approval for our study was obtained from the Chinese National Archery Association, and all study procedures were in accordance with relevant guidelines.

2.2 Methods

2.2.1 2D:4D Measurement

We used the measurement method proposed by Kanchan [19], in which a digital camera fixed to a glass plate was used to photograph the hand, with the palm facing upward and naturally extended. By taking two photographs of each archer and importing them into Adobe® Photoshop® for processing, we obtained an average and more accurate set of data.

2.2.2 Specific Physical Fitness Tests

The Chinese and Korean archery specialists conducted a set of tests exclusive for these archers to evaluate their physical fitness. This set of physical fitness tests was designed by Chinese and Korean fitness experts for Chinese archery athletes, and the method has been approved and endorsed by the Chinese Archery Association. These tests included push-ups, decline sit-up, half-squat, and a 4000-meter run, and each part was scored from 1 to 4 and well controlled by the coaching teams from two countries to ensure data accuracy.

2.2.3 Results of Former Games

The study followed the scoring rules of the World Archery Federation and referred to those archers' results of their former ranking tournaments and Olympic elimination series. Given that an archer shall shoot 144 arrows in his or her ranking tournaments, one must keep a high degree of "consistency" in their technical movements. Moreover, the elimination series highlighted uncertainties in their performance. Both events were held under the supervision of international archery judges, so the data obtained were truly reliable.

2.2.4 Statistical Analysis

The study recorded every entry of data in a "mean $\pm$ standard deviation" (M $\pm$ SD) format and processed them in SPSS 24.0 (IBM Corp., Chicago, IL, USA) to produce One-Way ANOVA and Pearson correlations. These two key indicators helped to clarify two relations, namely, the differences between the left and right hands of archers of various levels, and the correlation between their left and right 2D:4D and their results from both physical fitness tests and sporting performance.

3 Results

3.1 The Comparison of 2D:4D Difference of Elite Archers of Various Levels

Fig. 1 shows both left and right 2D:4D of 31 elite archers, indicating no significant differences of left 2D:4D between world-class, national-level, and level-1 athletes ($p > 0.05$), and between world-class and national-level athletes ($p > 0.05$), yet a significant difference of right 2D:4D between world-class, national-level, and level-1 athletes ($p < 0.01$).

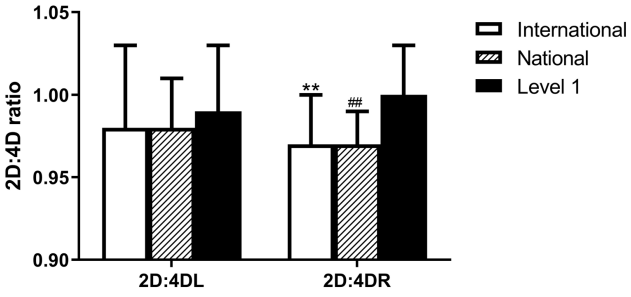

Fig. 1. 2D:4D Difference of elite archers of various levels ($p < 0.05$).**

3.2 The Correlation between 2D:4D and Specific Physical Fitness Tests

Fig. 2 presents the correlation between 2D:4D and specific physical fitness of Chinese elite archers, showing no significant correlation between the left 2D:4D and their test results ($p > 0.05$), yet a significant negative correlation between the right 2D:4D and specific physical fitness test results ($p < 0.05$).

Table 1. Basic information of Chinese elite archers.

	Age (year)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Training time (year)
Male	21.5 ± 3.8	178.8 ± 4.6	84.6 ± 15.7	25.2 ± 4.9	8.8 ± 4.2
Female	20.8 ± 3.7	171.1 ± 4.6	68.0 ± 9.7	21.9 ± 2.5	8.8 ± 3.1

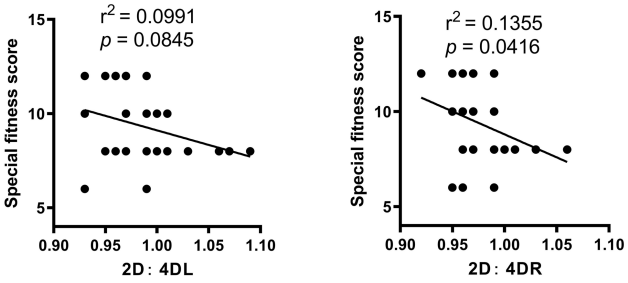

Fig. 2. The correlation between 2D:4D and physical fitness test results.

3.3 The Correlation between 2D:4D and Sporting Performance

Fig. 3 clarifies the correlation between 2D:4D and sporting performance of Chinese elite archers. Similarly, we found no significant correlation between the left 2D:4D and their results from former games. It is noteworthy that there was a significant negative correlation between the right 2D:4D and their results in former ranking tournaments ($p < 0.01$) and Olympic elimination series ($p < 0.01$).

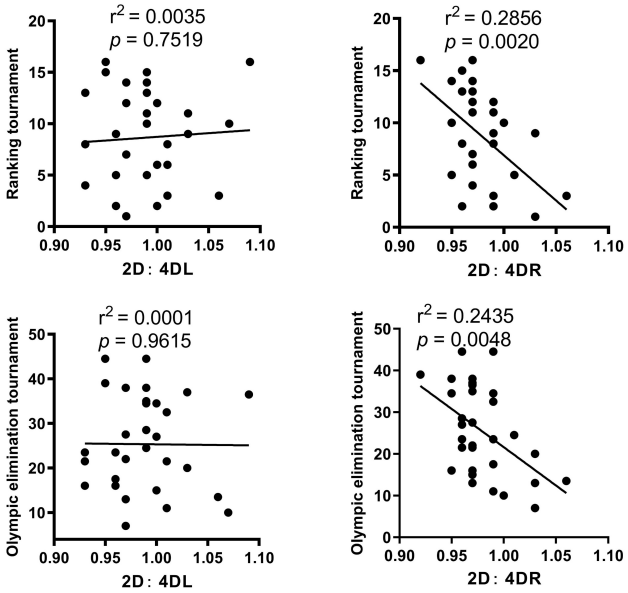

Fig. 3. The correlation between 2D:4D and sporting performance.

4 Discussion

It can be concluded from the above analysis that 2D:4D of elite archers negatively correlates with their specific physical fitness and games results which was consistent with the previous hypothesis. With this result we can offer a proposal for better high-calibre archer selection. Due to the limitation of time, all archers participating in this test are high-level archers, and the data of archers of other grades have not been obtained. Whether they also have this phenomenon remains to be verified. It is hoped that researchers can collect more data of archers of different grades in the future to verify the results of this study.

Previous literature has demonstrated that variability in the finger length ratio between males and females exists [20], so in order to avoid the influence of this issue on the results of this experiment, the number of males and females in this experiment was almost equal, and the basic information for both males and females also fluctuated within a certain range (Table 1).

4.1 The 2D:4D Differences between Elite Archers of Different levels in China

By comparing 2D:4D between archers of various levels, we found no significant difference in the left 2D:4D between them, and in the right 2D:4D between world-class and national-levels archers, yet a significant difference between world-class, national-level, and level-1 athletes, and a negative correlation between the right 2D:4D and their sporting competence. In short, the higher the sporting competence in archery, the lower the right 2D:4D, a conclusion corresponding to earlier findings. For instance, a study comparing 2D:4D of elite and non-elite wrestlers found that elite wrestlers had lower 2D:4D than non-elite wrestlers and their right 2D:4D were more significantly lower than the left one [21]. Another study on 2D:4D of multi-level English football players found that excellent team players had lower 2D:4D than younger ones and national team players than non-national ones, and 2D:4D was negatively correlated with their sporting competence [22]. As to Chinese elite athletes, research found that swimmers' sporting competence was negatively correlated with their 2D:4D [23], and 2D:4D of elite fencers was significantly lower than that of non-elite ones [24]. Given the close relation between the finger length ratio and the prenatal uterine testosterone concentration, the ratio is often used as an important body morphological marker to evaluate prenatal uterine testosterone concentration [8]. Moreover, human fingers are sensitive to different hormones. For instance, 2D is sensitive to oestrogen, while 4D is sensitive to androgens [25]. Therefore, world-class archers exposed to relatively high level of hormones and androgens in their foetal period probably display higher 2D:4D than other players.

4.2 The Relations between 2D:4D and Specific Physical Fitness Test Results

Archery, though accuracy-oriented, also demands a high level of muscular strength and endurance [26]. In this study, we collected those elite archers' physical fitness test results before they took part in ranking tournaments and elimination series, to ensure the data retrieved was credible. As was statistically evident, there was a significant negative correlation ($p < 0.05$) between the right 2D:4D and physical fitness test results, and it was consistent with the previous hypothesis.

Recently, molecular genetics has revealed that human athletic ability is closely related to innate genetic factors, in which the finger length ratio, a stable human morphological indicator, is regarded to be correlated with human's health level, athletic ability, and cognitive level [27]. Earlier studies confirmed its relevance with testosterone levels in utero, a crucial factor related to muscle mass, strength, and physical performance [28]. Hence, a lower 2D:4D tends to indicate a higher testosterone level, and people with lower 2D:4D may have better muscle strength, endurance, and cardiorespiratory fitness than those with higher ones. After studying college students, one study, however, concluded that the left 2D:4D correlated to human athletic ability [29], and other studies believed that the smaller the left 2D:4D, the higher the running efficiency for athletes [30]. As to the right 2D:4D, it significantly correlates with specific physical fitness and sporting performance of elite archers, which is different to that of the left 2D:4D. Furthermore, factors like sporting competence, race, and region amplify such difference, and further studies shall highlight the relation between 2D:4D and players' athletic ability.

4.3 The Relations between 2D:4D and Sporting Performance

This study revealed a strong negative correlation between the right 2D:4D and archers' results of ranking tournaments ($p < 0.01$) and Olympic elimination series ($p < 0.01$). Similarly, one study found that Australian semi-professional female basketball players with lower 2D:4D performed better and were more likely to be in the starting team [31], and our study agrees with this. Another study, also on these female players, found that athletes with lower 2D:4D performed better on defence such as rebounding and blocking [32]. As discussed above, foetuses with larger finger-length ratios have higher-level testosterone and androgens in utero [33], the latter of which has been shown to affect foetal central nervous system differentiation, operant ability, spatial vision, and development of both right brain and cardiopulmonary systems [34]. Due to better right-hemisphere brain development, individuals with lower 2D:4D possess enhanced visual-spatial processing competence. Considering that archery demands a high level of central nervous system differentiation, manipulation, spatial vision, and right-brain development, athletes with lower 2D:4D have better game results.

5. Conclusions

Chinese elite archers with lower right 2D:4D are of better physical fitness and sport performance. Hence, the right 2D:4D can act as a critical indicator in selecting excellent archers.

Author Contributions

JW and XLL—extraction and drafting of the manuscript; YJW and YLZ—analysis of data, manuscript revision; YZF—design and revision, statistical analysis.

Ethics Approval and Consent to Participate

All players were Han nationality to exclude possible ethnic differences in 2D:4D, and they each gave informed consent. In addition, we likewise obtained informed consent from the guardians of these minor archery athletes under the age of 18 years. Ethical approval for our study was obtained from the Chinese National Archery Association (2018A102), and all study procedures were in accordance with relevant guidelines.

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Conflict of Interest

The authors declare no conflict of interest.

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