Int. J. Morphol.,
42(6):1755-1760, 2024.

The Relationship Between Digit Ratio (2D:4D), Physical Fitness Indicators and Pulmonary Function in Chinese College Students

Relación entre la Proporción de los Dedos (2D:4D), los Indicadores de Aptitud Física y Función Pulmonar en Estudiantes Universitarios Chinos

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ZHAN, Y. & CHO, C. The relationship between digit ratio (2D:4D), physical fitness indicators and pulmonary function in Chinese college students. *Int. J. Morphol., 42(6)*:1755-1760, 2024.

SUMMARY: To investigate the relationship between the 2D:4D ratios and physical fitness of ordinary Chinese college students, 742 Chinese college students (219 men, 523 women) aged 18 to 21 years were randomly selected. The lengths of the index fingers and ring fingers of the left and right hands were measured and the 2D:4D ratio was calculated. The difference in digit ratio between the right and left hands (Dr-l) was also calculated. The physical fitness items measured included height and weight (calculated using BMI), forced vital capacity, the sit-and-reach, 50-meter run, standing broad jump, pull-up test, and 1000-meter run for men, and the one-minute sit-up test and 800-meter run for women. The comparison between men and women was performed using an independent-sample t-test, and the comparison of the 2D:4D ratios of the left and right hands of the same sex was performed using a paired-sample t-test. The Pearson correlation coefficient was used to determine the relationship between the 2D:4D ratio and physical fitness. Statistical significance was set at $p < 0.05$. We found that the L2D:4D ratios of men were positively correlated with body weight and BMI, and negatively correlated with standing broad jump and pull-up. The 2D:4D ratios of women were negatively correlated with forced vital capacity and positively correlated with sitting forward bend and one-minute sit-ups, and their R2D:4D ratios were positively correlated with their sit-and-reach. In the present study, L2D:4D was found to be more closely related to physical fitness than R2D:4D. These results suggest that digit ratio, especially the 2D:4D ratio of the left hand, have a greater potential impact of prenatal androgen exposure and may be a key parameter in predicting physical fitness in non-athlete young adults, regardless of sexo.

KEY WORDS: Digit ratio; Physical fitness; 2D:4D.

INTRODUCTION

The digit ratio(2D:4D), defined as the relative length of the index finger(2D) to the ring finger(4D), has garnered considerable attention in scientific research due to its association with prenatal sex hormones and its implications for various aspects of human physiology and behavior (Manning *et al*., 2000). It is widely recognized that the 2D:4D ratio tends to be lower in males compared to females, a trait influenced by prenatal hormonal exposure, particularly testosterone and estrogen levels during early fetal development (Manning *et al*., 1998).

Zheng & Cohn (2011) suggest that exposure to high levels of prenatal testosterone provides long-term tissue benefits such as better cardiovascular, musculoskeletal, and genitourinary growth and development. Consequently, numerous studies have suggested a link between digit ratio and athletic prowess, with a lower 2D:4D ratio often associated with enhanced performance in various sports disciplines and measures of physical fitness. For instance, Manning & Taylor (2001) observed significantly lower 2D:4D ratios in professional football players compared to controls, with international athletes exhibiting similarly lower ratio. Moreover, a significant negative correlation has been established between the 2D:4D ratio and sports performance across multiple disciplines, including rugby, skiing, wrestling, long-distance running, gymnastics, and fencing (Bennett *et al*., 2010).

On the other hand, health is a multidimensional concept that transcends the mere absence of illness, encompassing mental, social, emotional, spiritual, and physical well-being (Corbin *et al*., 2009). These dimensions are influenced by both genetic predispositions and individual capabilities with physical fitness in particular

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Received: 2024-08-06 Accepted: 2024-08-11

playing a key role in maintaining overall health and reducing the risk of chronic disease (Fogelholm, 2010). From this perspective, the 2D:4D ratio could be used not only as a predictor of fitness but also as an indicator of future health conditions.

However, existing studies have primarily focused on professional athletes outside China and individuals engaged regularly in physical exercise, often with limited sample sizes. Notably, research on the Chinese population, particularly non-athletes, remains scarce, highlighting the need for further investigation. With this purpose, this research examined the relationship between the 2D:4D ratio and physical fitness and lung function of ordinary male and female college students in China.

MATERIAL AND METHOD

Subjects. A total of 742 Chinese college students aged between 18 and 21 were haphazard sampling, of which 219 were males and 523 were females. None of the participants had any special sports training. The purpose of the study and the study protocol were explained to all participants, and they voluntarily agreed to participate in this study. Each participant signed an informed consent form before conducting the study.

Experimental procedures

Physical fitness measurement. China's current college student physical fitness test system began in 2002 and was revised in 2014, stipulating that every college student should take a physical fitness test every year. In the present study, the physical fitness items for Chinese college students included height, weight, body mass index(BMI), forced vital capacity, the sit-and-reach, 50-meter run, standing broad jump, pull-up test, 1000-meter run for men, the one-minute sit-up test, and 800-meter run for women. The test equipment was selected from the equipment designated by the Ministry of Education of China (HENGKANG HK6800, China), and the test method followed the guidelines outlined in the 'National Physical Health Standards for Students' issued by the Ministry of Education of China.

1) Height: Height was measured to the nearest 0.1cm using an electronic stadiometer (HENGKANG HK6800-ST, China) and was measured in an upright position with bare feet (the upper limbs hanging down naturally, heels close together, and toes pointing outward at a 60-degree angle).
2) Body weight: Body weight was measured to the nearest 0.1kg using an electronic scale (HENGKANG HK6800-ST, China), with participants donned in light clothing(men: shorts, women: shorts and short-sleeved shirt).
3) Forced vital capacity (FVC): Forced vital capacity was measured using a spirometer (HENGKANG HK6800-FH, China). Subjects were instructed to stand facing the spirometer and hold the mouthpiece. After one or two deep breaths, they inhaled deeply, held their breath, and then exhaled slowly through the mouth until unable to exhale further, avoiding inhalation during exhalation. Each subject underwent three tests with a 15-second interval, and the highest recorded value was considered the test result, with a measurement accuracy of 1ml.
4) Sit-and-reach: Flexibility through sit-and-reach test was measured to the nearest 0.1cm using a sit-and-reach test instrument (HENGKANG HK6800-TQ, China). The subjects sat with their legs outstretched and pushed their feet flat against a longitudinal board. They gradually pushed the measurement cursor forward with the tips of their middle fingers until it stopped. Each subject underwent the test twice, with their best scores recorded.
5) 50-meter sprint: The 50-meter sprint was measured to the nearest 0.01 seconds using a laser measuring system (HENGKANG HK6800-PB, China). Subjects ran in groups of at least two, starting upon hearing the command "run" and the waving of the starting flag by the starter. The timekeeper initiated the stopwatch upon flag movement and stopped it as soon as a subject's torso reached the vertical plane of the finish line.
6) Standing broad jump: Standing broad jump was measured to the nearest 0.1 cm using an automatic measuring device (HENGKANG HK6800-LT, China). The subjects stood behind the starting line with their feet naturally apart. Subjects were instructed to take off and land on both feet. Each subject underwent the test three times, with their best scores recorded.
7) Pull-up (male): Pull-ups were measured using an measuring device (HENGKANG HK6800-YT, China) to determine the number of perfect pull-ups performed. The subjects jumped up and grasped a horizontal bar with both hands, with their hands shoulder-width apart and arms hanging straight. After resting, they used both arms to vigorously pull up in one fluid movement (no additional movement of the body) until the lower jaw exceeded the upper edge of the bar to complete one repetition.
8) One-minute sit-up (female): One-minute sit-ups were measured using an measuring device(HENGKANG HK6800-YW(HW), China). Subjects lay supine on the mat, legs slightly separated, knees bent at an angle of approximately 90 degrees, with their fingers interlaced behind their heads. Another participant held the subject's ankles to immobilize their lower limbs. When the subjects sat up, their elbows touched or passed their knees to complete one repetition. When lowering back down, their shoulder blades were required to touch the mat.
9) 800-meter (female) or 1000-meter(male) run: The 800m or

1000m run was measured to the nearest 0.01 seconds using a laser measuring system(HENGKANG HK6800-CP, China). The subjects were tested in groups of at least two and started in a standing position. They started running upon the command "run". When the timekeeper saw the movement of the starting flag, he started the clock, then stopped timing when the subject's torso reached the vertical plane of the finish line.

2D:4D ratio. Finger-length measurement refers to the method described by Manning *et al*. (1998), where the second and fourth fingers of the left and right hands are measured (Bennett *et al*., 2010). The subjects were asked to remove finger ornaments and place both hands palm-up on the table. Mitutoyo digital calipers were used to measure the length of the index finger (2D) and ring finger (4D) of both hands (the measurement was accurate to 0.01mm). Finger lengths were measured from the ventral side of the hand, from the midpoint of the finger crease near the palm to the fingertip. The length of each finger was measured twice by the same observer in the same manner, and the average value was calculated. The subjects' 2D:4D ratios were calculated by dividing the length of 2D by the length of 4D.

Statistical analysis. The data were statistically analyzed using SPSS 21.0 (IBM, U.S.A). After removing outliers using the box plot method, the normality of the data was assessed using the Kolmogorov–Smirnov test. The comparison between men and women was performed using an independent-sample t-test, and the comparison of the 2D:4D ratios of the left and right hands of the same sex was performed using a paired-sample t-test. Pearson correlation coefficients were used to determine the relationship between 2D:4D ratio and physical fitness, and all results were reported as mean ± SD, with $P < 0.05$ considered statistically significant.

RESULTS

Descriptive statistics of 2D:4D ratio and physical fitness index. Table I presents the mean values of the 2D:4D ratio and physical fitness indicators. The 2D:4D ratios of males' left and right hands were significantly lower than those of the hands of females (left hand: $t(740) = -3.282$, $p = 0.001$; right hand: $t(740) = -6.655$, $p < 0.001$). There was no significant difference in the 2D:4D ratio between the left and right hands of males ($t(218) = 0.450$, $p = 0.653$), while the 2D:4D ratio of the right hand was significantly higher than that of the left hand in females ($t(522) = -4.346$, $p < 0.001$). The physical fitness indicators showed that women had significantly higher sit-and-reach ($t(740) = -11.226$, $p < 0.001$), while men had significantly higher values for height, weight, BMI, FVC, 50-meter run, and standing broad jump ($p < 0.001$).

Associations between 2D:4D ratios and physical fitness parameters. Table II presents the Pearson correlation coefficients between the 2D:4D ratios of men and women and physical fitness indicators. Among men, the L2D:4D ratio showed a significant correlation with the R2D:4D ratio ($r = 0.435$, $p < 0.01$), body weight ($r = 0.204$, $p < 0.01$), and BMI ($r = 0.221$, $p < 0.01$), as well as the standing broad jump ($r = -0.182$, $p < 0.01$) and pull-up ($r = -0.136$, $p < 0.05$). However, no significant correlation was found between the R2D:4D ratio and physical fitness index. Among women, the L2D:4D ratio showed a significant correlation with the R2D:4D ratio ($r = 0.471$, $p < 0.01$), FVC ($r = -0.117$, $p < 0.01$), and sit-and-reach ($r = 0.108$, $p < 0.05$) and one-minute sit-up test ($r = 0.123$, $p < 0.01$). The R2D:4D ratio was significantly correlated with the one-minute sit-up ($r = 0.125$, $p < 0.01$) .

Table I. Descriptive statistics of 2D:4D ratio and physical fitness index (m ± SD).

Variables	Men (n=219)	Women (n=523)
L2D:4D	0.967±0.034	0.976±0.037**
R2D:4D	0.966±0.036	0.983±0.031***
Height (cm)	171.46±6.13	159.70±5.62***
Weight (kg)	65.90±10.76	53.25±7.75***
BMI (kg/m^2)	22.403±3.35	20.85±2.61***
FVC (ml)	3,539.21±587.69	2,629.41±41.11***
Sit-and-reach (cm)	13.08±7.06	19.08±6.46***
50-meter run (s)	7.96±0.52	9.53±0.59***
Standing broad jump (cm)	219.71±23.06	171.06±15.58***
One-minute sit-up	-	33.52±6.61
Pull-up	6.44±5.88	-
800-meter run (s)	-	234.25±21.47
1000-meter run (s)	249.46±27.68	-

**p<.01, ***p<.001.

Table II. Correlation between 2D:4D and physical fitness indicators.

Variables	Men		Women	
	L2D:4D	R2D:4D	L2D:4D	R2D:4D
L2D:4D	1	0.435**	1	0.471**
R2D:4D	0.435**	1	0.471**	1
Height (cm)	0.018	-0.03	-0.054	0.015
Weight (kg)	0.204**	0.059	-0.076	-0.038
BMI (kg/m^2)	0.221**	-0.084	-0.057	-0.051
FVC (ml)	-0.007	-0.003	-0.117**	-0.017
Sit-and-reach (cm)	0.036	0.052	0.108*	0.125**
50-meter run (s)	0.077	0.085	0.013	0.035
Standing broad jump (cm)	-0.182**	-0.045	0.079	0.035
One-minute sit-up(number/m)			0.123**	0.075
Pull-up(number/m)	-0.136*	-0.008		
800-meter run (s)			-0.041	-0.059
1000-meter run (s)	0.083	0.081		

*p<.05,**p<.01.

DISCUSSION

In this study, we explored the relationship between 2D:4D ratios and the physical fitness of Chinese college students. In males, significant correlations were observed between digit ratio and fitness factors, mainly in the left hand analysis, with BMI, standing long jump, and pull-ups being significantly associated with L2D:4D. In females, left hand digit ratio was correlated with fitness factors, especially FVC, sit-and-reach, and 1-minute sit-ups, and was also significantly associated with sit-ups and R2D:4D.

Our investigation revealed a positive correlation between the L2D:4D ratio and body weight, as well as BMI, in men. However, this correlation failed to reach statistical significance in females, consistent with previous research by Fink *et al.* (2003).BMI, a widely used indicator of weight status, provides valuable insights into obesity rates, which are linked to increased estrogen levels in both men and women (Kley *et al*., 1980), a trend partially supported by our findings.

Despite a BBC(British Broadcasting Corporation) study unveiling a weak positive relationship between the 2D:4D ratio and BMI, especially in women (Manning *et al*., 2022), it's noteworthy that this study relied on self-measurements via a web survey, introducing potential biases. Various studies present conflicting results; for instance, Kobus *et al*. (2021) found a positive correlation between the R2D:4D ratio and BMI for boys and girls aged 6-13. Conversely, Ranson *et al*. (2015) found that only girls' R2D:4D ratios were correlated with BMI in a study involving over 1,700 Welsh children aged 8-12. It's crucial to recognize that these studies involved adults over 18, spanning a wide age range (Erkec, 2019), whereas our study focused specifically on college students aged 18-21, suggesting that age differences among subjects may contribute to divergent research findings.

Androgens play a pivotal role in stimulating the growth and development of skeletal muscles, which significantly contribute to strength and movement. Numerous studies have demonstrated a significant association between finger proportions and athletic performance, physical fitness levels, and success in various sports (Bennett *et al*., 2010). The standing broad jump, as an indicator of explosive power, revealed a significant negative correlation with the male L2D:4D ratio in our study. Previous studies have also indicated a weakly negative correlation between a lower 2D:4D ratio in men and explosive muscular strength, such as vertical jump performance (Disterhaupt *et al*., 2022). However, Koziel *et al*. (2017) found no relationship between the 2D:4D ratio and the standing broad jump among Polish military academy students, possibly due to specific physical characteristics unique to military academy students.

Pull-ups are a common measure of upper-body strength endurance. The results of this survey found that only men's L2D:4D is negatively correlated with pull-ups. Grip strength has generally been used in previous studies on the relationship between strength and 2D:4D ratio. Tomkinson & Tomkinson (2017) discovered a negative correlation between the 2D:4D ratio and grip strength in American adolescent boys. Similar findings were reported in a study involving school-aged children (Ranson *et al*., 2015). This is similar to the results of this study. However, Kociuba *et al*. (2019) study found a more pronounced relationship in women. A study of Han college students in Ningxia, China,

revealed a negative correlation between the 2D:4D ratios of both hands and grip strength only in women, not in men (Shen *et al*., 2016). Conversely, Zhao *et al.* (2013) found a negative correlation between the R2D:4D ratio and grip strength in adult males of Hani nationality in China. These discrepancies may be attributed to variations in the test subjects, as the 2D:4D ratio exhibits population differences (Lombardo & Otieno, 2021).

This study revealed a negative correlation between the L2D:4D ratios of college women and FVC (forced vital capacity). Previous studies have rarely examined the relationship between FVC and the 2D:4D ratio. One study involving 25 male football players reported a positive correlation between the L2D:4D ratio and FVC (Yilmaz, 2023), while another study conducted on hospitalized patients in South Korea found a positive correlation between the R2D:4D ratio and FVC in non-smoking males (Park *et al*., 2014). These findings contradict the results of the present study.

Furthermore, this study discovered a positive correlation between the R2D:4D ratios of college women and one-minute sit-ups, as well as a negative correlation between the 2D:4D ratios of both hands and sit-and-reach. In contrast, Peeters *et al*. (2013) conducted an X-ray study involving 178 girls aged 5-18 and found no association between the L2D:4D ratio and any measure of physical fitness. This finding is inconsistent with the results of the present study.

The 2D:4D ratio is increasingly recognized as a possible biomarker for athletic potential, with lower ratios observed in sport-specific athletes compared to non-athletes and elite athletes compared to non-elite athletes (Manning, & Taylor, 2001). Previous studies have also suggested that the relationship between male fitness and the 2D:4D ratio may be influenced by exercise frequency (Hönekopp *et al*., 2006). If a similar "mediation effect" exists in Chinese college students, the inclusion of individuals who have not received physical training and are predominantly sedentary may impact the indirect relationship between the 2D:4D ratio and physical fitness.

Moreover, the negative correlation between digit ratio and sports performance in various activities may be attributed to the potential association between the 2D:4D ratio and acute increases in testosterone levels during competition, as most studies have not found a statistically significant correlation between the 2D:4D ratio and adult sex hormones(Kim & Kim, 2016). Although physical fitness measurements were incorporated into student evaluations, it's essential to acknowledge potential limitations, including variations in effort exerted during tests and the specificity of physical fitness tests tailored to Chinese college students.

In conclusion, this study examined the relationship between the 2D:4D ratio and physical fitness in non-athlete Chinese college students. Among men, the L2D:4D ratio showed positive correlations with body weight and BMI, while displaying negative correlations with standing broad jump and pull-up. Among women, the L2D:4D ratio exhibited a negative correlation with FVC, and positive correlations with the sit-and-reach and one-minute sit-up test. The R2D:4D ratio showed positive correlations with the sit-and-reach in women. In the present study, L2D:4D was found to be more closely related to physical fitness than R2D:4D. These results suggest that digit ratio, especially the 2D:4D ratio of the left hand, have a greater potential impact of prenatal androgen exposure and may be a key parameter in predicting physical fitness in non-athlete young adults, regardless of sex. Further research addressing the limitations highlighted herein, including regional variations and methodological differences will enhance our understanding of these complex relationships.

ACKNOWLEDGMENTS. We would like to express our sincere gratitude to all individuals who contributed to the completion of this research endeavor. Firstly, we extend our appreciation to the participants of this study, whose cooperation and involvement were instrumental in gathering the necessary data. We are thankful to the faculty and staff of the participating universities for their assistance in facilitating the research process. Their support and cooperation were invaluable in ensuring the smooth execution of the study.

ZHAN, Y. & CHO, C. Relación entre la proporción de los dedos (2D:4D), los indicadores de aptitud física y la función pulmonar en estudiantes universitarios chinos. *Int. J. Morphol., 42(6)*:1755-1760, 2024.

RESUMEN: Para investigar la relación entre las proporciones 2D:4D y la aptitud física de estudiantes universitarios chinos, se seleccionaron al azar 742 estudiantes universitarios (219 hombres, 523 mujeres) de entre 18 y 21 años. Se midieron las longitudes de los dedos índice y anular de las manos izquierda y derecha, y se calculó la proporción 2D:4D. También se calculó la diferencia en la proporción de los dedos entre las manos derecha e izquierda (Dr-l). Los ítems de aptitud física medidos incluyeron altura y peso (calculados usando IMC), capacidad vital forzada, sit-and-reach, carrera de 50 metros, salto de longitud de pie, prueba de pull-up y carrera de 1000 metros para hombres, y la prueba de abdominales de un minuto y carrera de 800 metros para mujeres. La comparación entre hombres y mujeres se realizó usando una prueba t de muestra independiente, y la comparación de la relación 2D:4D de las manos izquierda y derecha del mismo sexo se realizó usando una prueba t de muestra pareada. El coeficiente de correlación de Pearson se usó para determinar la relación entre la razón 2D:4D y aptitud física. La significación estadística se estableció en $p < 0,05$. Encontramos que la relación L2D:4D de

los hombres estaban correlacionadas positivamente con el peso corporal y el IMC, y negativamente correlacionadas con el salto de longitud de pie y la pull-up. Las proporciones 2D:4D de las mujeres se correlacionaron negativamente con la capacidad vital forzada y positivamente con la inclinación hacia adelante en posición sentada y los abdominales de un minuto, y sus proporciones R2D:4D se correlacionaron positivamente con la capacidad para sentarse y alcanzar objetos. En el presente estudio, se encontró que L2D:4D estaba más estrechamente relacionada con la aptitud física que R2D:4D. Estos resultados sugieren que la proporción de los dedos, especialmente la proporción 2D:4D de la mano izquierda, tiene un mayor impacto potencial de la exposición prenatal a los andrógenos y puede ser un parámetro clave para predecir la aptitud física en adultos jóvenes no deportistas, independientemente del sexo.

PALABRAS CLAVE: Proporción de dedos; Aptitud física; 2D:4D

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