Original Articles

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The relationship between digit ratio (2D:4D) and physical fitness in boys 7 to 13 years

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B – Data Collection
C – Statistical Analysis
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E – Funds Collection

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Abstract

The relative lengths of the index finger to the ring finger (2D:4D) is sexually dimorphic. It is believed that the 2D:4D negatively correlates with prenatal testosterone and positively with prenatal estrogen. Low 2D:4D is related to masculine traits such as aggression, physical fitness and performance in different sports. The aim of this study is to investigate the relationship between the 2D:4D and physical fitness among 7 to 13 year-old boys. 316 boys were selected, all participants were in pre-pubertal stage. After completing the consent by their parents; height, weight, lengths of the index and ring fingers and physical fitness such as: strength, muscle endurance, power, speed, agility, flexibility and aerobic fitness were measured. The partial correlation coefficients was used to determine association between variables. Data analysis was done by SPSS software, version 20, and the level of significance was considered as P≤0.05. The results showed that the digit (2D:4D) ratio has no significant correlation with handgrip strength and aerobic fitness (P >0.05). Also, according to the results, no correlation has been observed between the 2D:4D and muscle endurance, power, speed, agility and flexibility (P > 0.05). It seems that 2D:4D is associated with level of testosterone and prenatal estrogen; this index has no significant correlation with physical fitness in children and cannot be used to identify and discover talented individuals for various sporting fields. However, more researches are still needed in this area.

Keywords: *Children, Handgrip Strength, 2D:4D, Testosterone, Physical Fitness.*

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INTRODUCTION

Childhood is the most physically active stage of human development. Children like to play games and participate in physical activities and sports, and they certainly love to compete. In today's society, sport has become a way of life. Parents plan their vacations and days off work around hockey and soccer tournaments, and children dream about developing into professional athletes, buying jerseys, hats, stickers, and even video games that promote their favorite players. Coaches are bombarded with various training philosophies, equipment, and scrutiny from parents, administrators, other coaches, and athletes [1,2].

Children of the same chronological age may differ by several years in their level of biological maturation. Moreover, while an early-maturing child may show dramatic improvements initially, often a late mature will be the better athlete in the long run. Current research in athletic training substantiates such a claim; thus, it's important to look beyond the short-term achievements and let children develop at their own pace [1].

Many children strive to attain excellence in sport. However, although talent identification and development programs have gained popularity in recent decades, there remains a lack of consensus in relation to how talent should be defined or identified and there is no uniformly accepted theoretical framework to guide current practices [2]. Many sport scientists and coaches believed that talent identification is a critical component of elite sports development programs [3]. Talent identification has long been of great interest to coaches, administrators, communities, and governments [4,5]. These fields are united in many societies around the world by high levels of competition to achieve success against limited financial resources [4]. Talent identification (i.e. the process of recognizing current participants with the potential to excel in a particular sport) and talent development (i.e. providing the most appropriate learning environment to realize this potential) play a crucial role in the pursuit of excellence [2,5].

The study of relationships between physical characteristics and sport performance can help to identify a set of limitations and abilities in sport [3,6]. Physical fitness however cannot be assessed by a single test and consists of multiple distinct aspects such as balance, flexibility, speed of limb movement, sprinting speed, endurance and static, power, functional, and trunk strength as is evidenced by factor analyses [7].

Hand parameters, especially digit ratio, are a rich resource of stable and valuable information about the abilities of people. Meanwhile, the second to fourth digit ratio (2D:4D) is a calculable and powerful variable for predicting the talents and abilities of athletes [3,6]. 2D:4D ratio (the length of the second finger divided by the length of the fourth finger) appears to be a marker of prenatal testosterone levels, in which lower 2D:4D indicating higher prenatal testosterone. 2D:4D has become a prominent tool for studying potential effects of prenatal testosterone on human development and behavior. Athletic performance is positively affected by circulating testosterone levels; similarly, prenatal testosterone may have a positive effect on athletic performance [8]. The Homeobox genes Hoxa and Hoxd control the development of the testes and ovaries, and also control the development of the digits [9]. Prenatal sex steroids have been broadly discussed in terms of their possible effect on brain differentiation, whereas pubertal/adult sex hormones are thought to be the main regulators of sexually dimorphic physical features in males and females [10]. Studies show that 2D:4D is relate to utero growth rate, the development of depression and mental disorders, morphology, risk of heart disease and bone mineral density [6,10,11].

A lower 2D:4D has been also reported to be related to high achievements in the following: men's professional football, and in a range of men's sports [12,13], female athletic ability [13], rugby, skiing and in track events including middle- and long-distance running [14,15,16].

Research on the relationship between children's 2D:4D and health and fitness is limited; also, the fingers is different in geographic regions and races therefore, for each area certain norms are required [17,18].

There are no studies that have examined the relationship between 2D:4D and physical fitness among Iranian boys. If physical fitness related to the effects of prenatal sex steroids, we could expect that 2D:4D will be correlated with fitness in pre-pubertal children. Therefore, the purpose of this study is to examine the relationship between 2D:4D ratio and physical fitness in Iranian boys. Although this issue has been examined in some Western societies, but no study has been done in Iran; in this regard and according to the race, culture, lifestyle and different climate differences, study in this field necessary. Obviously, if any connection is found between the 2D:4D and physical fitness in children, this index can be used in the development of talent identification programs in IRAN.

MATERIAL AND METHODS

This is a descriptive-correlation study. In which 316 healthy boys participated (primary schools and secondary schools). Based on their age range, the participants were classified in two groups (7-10 years and 11-13 years). The participants with any form of mobility problems, heart disease and diabetes, were excluded from the study (All participants were in pre-pubertal stage). Parent/guardian and pupil gave their consent and assent respectively and had the right to withdraw. University Ethics Committee approved the terms of the project. All fitness testing was performed at 8 to 12 am during the ninth session. Participants undertook a standardized 10-minute warm up consisting of jogging and dynamic stretches.

Body weight and height were measured with standard techniques with 0.1 kg and 0.5 cm tolerance, respectively. BMI was calculated as weight divided by height squared (kg/ m2). The digit ratio of the right hand was measured according to the method recommended by Manning et al (1998) [19]. The lengths of the index and ring fingers were measured on the palmar surface of the hand from the basal crease proximal to the palm to the tip of the finger using digital calipers (mitutoyo, model digimatic caliper 500-151-20, china) with the accuracy of 0.01 mm. After measuring the length of the fingers, again measurements were repeated and the mean of the two measurements was recorded. 2D:4D ratio was obtained by dividing the length of index finger to ring finger [19].

Also using the formula, age of puberty was calculated [20]:

Maturity Offset= -9.236 + 0.0002708×Leg Length and Sitting Height interaction - 0.001663×Age and Leg Length interaction + 0.007216×Age and Sitting Height interaction + 0.02292×Weight by Height ratio.

($R=0.94$, $R^2=0.891$, and $SEE=0.592$).

Physical Fitness Components

All children participated in the 20 m shuttle run to measure aerobic fitness, horizontal jump (HJ) and vertical jump (VJ) (Sargent Jump) test to examine power, 20 m sprint tests to assess the sprint performance, sit-up and push-up tests to evaluate the muscular endurance, sit and reach (SR) to quantifying the level of flexibility, 4 x 9 m tests for assess agility and Hand grip strength (HG) to measure strength (measured using a digital dynamometer (Seahan, model SH5003) and most of the children were right-handed and the reliability r=0.96 for present device was recognized high) [3,7,17,21-24].

Participants were given a demonstration and practice guidance before performing each test, and were encouraged throughout. The highest score was recorded for HG, SR, HJ and VJ in which the children had 3 attempts. In addition, using the formula Mahar et al (2011) VO_{2max} of subjects was calculated [25]:

$$VO2max = 41.76799 + (0.49261 \times PACER) - (0.00290 \times PACER^2) - (0.61613 \times BMI) + (0.34787 \times gender \times age)$$

PACER is the number of laps completed; for gender, 1boy and 0girl; and age is in years.

Also, using the formula Sayers (1999) peak power [26] and using the formula of Fox and Matthews 1974 average power [27] of subjects were calculated;

$$\text{Peak power (W)} = 60.7 \times \text{High jump (cm)} + 45.3 \times \text{weight (kg)} - 2055$$

$$\text{Average power (W)} = 2.21 \text{ x weight (kg) x } \sqrt{\text{High jump (cm)}}$$

Statistical Analysis

All data are presented as mean ± standard deviations of the mean. Before statistical analysis, the normal distribution and homogeneity of the variances were tested by Kolmogorov–Smirnov test (K–S test). Because the data were normal, in order to remove or reduce interferer factors (puberty effect) were used partial correlation coefficients between independent and dependent variables. Statistical operation of this study was performed using SPSS 20 software and Excel 2010. The significance level was considered P ≤ 0.05 at all stages.

RESULTS

Table 1. Characteristics and physical tests of the study population.

Variable	Mean±SD	
	7-10 years	**11-13 years**
Age (years)	8.65±1.37	11.92±1.10
Age of puberty (years)	13.83±0.72	14.25±0.43
Height (cm)	128.81± 24.97	151.07±10.99
Weight (kg)	28.28±6.77	38.52±9.29
BMI (kg/m^2)	15.46±4.78	17.21±3.40
2d (mm)	5.23±0.44	6.17±0.50
4d (mm)	5.46±0.41	6.31±0.52
2d:4d	0.97±0.08	0.98±0.03
Hand Grip Strength (kg)	9.68±4.42	15.88±5.38
20 M Sprint (S)	4.40±0.78	4.23±0.41
Sit-Up (number)	17.43±3.36	22.30±3.81
Push-Up (number)	8.11±3.9	12.33±5.63
Horizontal Jump (cm)	116.79±30.69	149.35±26.06
Vertical Jump (cm)	15.75±5.01	27.08±7.28
Peak Power (W)	396.11±101.79	512.85±146.85
(W) Average Power	207.99±91.07	350.83±114.09
4 × 9 m (s)	11.69±1.47	11.11±0.92
Sit and Reach (SR) (cm)	3.66±3.62	5.43±4.48
VO_{2max}(mL/kg/min)	29.52±9.33	41.76±11.84

Table 2: Relationships (partial correlation coefficients) between 2d:4d and physical fitness.

Variable	Correlation	p-value	Correlation	p-value
	11-13 years		**7-10 years**	
Hand Grip Strength	07.-0	0.45	-0.11	0.31
Sit-Up	-0.06	0.95	-0.01	0.89
Push-Up	-0.03	0.68	-0.02	0.84
20 m Sprint	-0.05	0.55	-0.09	0.40
Horizontal Jump	-0.06	0.94	-0.11	0.30
Vertical Jump	-0.01	0.84	-0.02	0.83
Peak Power	-0.10	0.24	-0.06	0.58
Average Power	-0.07	0.41	-0.02	0.81
4 × 9 m	-0.05	0.58	-0.09	0.08
Sit and Reach	-0.05	0.57	-0.12	0.26
VO_{2max}	-0.04	0.79	-0.11	0.09

A total of 316 boys were selected to participate in this study. The characteristics and physical tests of the study population at the baseline are shown in table 1. Partial correlation coefficients between 2D:4D with physical fitness (strength, muscle endurance, power, speed, agility, flexibility and aerobic fitness) in two groups (7-10 years and 11-13 years) have been shown in table 2.

The results showed that the 2D:4D ratio was not significant correlation with handgrip strength and aerobic fitness in two groups ($P < 0.05$). Also, according to the results, was not observed correlation between the 2D:4D ratio with muscle endurance, power, speed, agility and flexibility in two groups ($P < 0.05$) (table 2).

DISCUSSION

The aim of the present study was to investigate the relationship between 2D:4D ratio and physical fitness in boys. The results show that the 2D:4D ratio has no significant correlation with strength, muscle endurance, power, speed, agility, flexibility and aerobic fitness.

Our findings are consistent with the finding Folland et al. (2012), Mehdizadeh et al (2013), Peeters et al (2013) and Nicolay and Walker (2005).

Folland et al. (2012) indicate that there is no significant association between 2D:4D and knee extensor strength in Caucasian men [28]. This finding is contrary to all the studies investigating the relationship between male 2D:4D and handgrip strength [28]. One possible explanation is that 2D:4D is a measure of hand anatomy and may be associated with the structure and function of the hand musculoskeletal system, and hence grip strength, rather than any systemic difference in whole body or locomotor muscle strength [28].

In this regard, Van Anders (2007) found no significant association between 2D:4D and grip-strength in a sample containing 99 women (mean age 23.76 years) [29]. They suggest that the widespread relationship between 2D:4D and sport performance may have more to do with aerobic efficiency than with strength and acceleration [29].

Also, Results of Mehdizadeh et al (2013) showed that there is no significant correlation between 2D:4D with dynamic muscular endurance (pull-up and push-up scores) [3]. Generally, it was concluded that muscular endurance cannot be predicted by anthropometric dimensions [3]. Peeters et al (2013) stated that left hand 2D:4D ratio is not significantly correlated with any of the physical fitness components (balance, speed of limb movement, flexibility, explosive strength, static strength, trunk strength, functional strength, running speed/agility, and

endurance), nor any of the anthropometric variables (stature, mass, BMI, somatotype components) in Flemish children (aged 6–18 years) [7]. 2D:4D ratio did not enter the multiple stepwise regressions for any of the physical fitness components in which other anthropometric traits explained between 9.2% (flexibility) and 33.9% (static strength) of variance [7]. Also, they stated unlike other anthropometric traits the 2D:4D ratio does not seem to be related to any physical fitness component in adolescent girls and therefore most likely should not be considered in talent detection programs for sporting ability in girls [7].
In addition, the findings of Nicolay and Walker [30] stated that in contrast to absolute force, muscular endurance (grip endurance) can't be predicted by hand dimensions. They believed that muscular endurance is affected not only by biochemical and tissue features of cells but also by individual motivations, nutrition status, tolerance to the accumulation of metabolic products and some other factors. Because none of the factors are related to a gross anatomy, determining muscular endurance through simple linear measurement and predicting muscular endurance through morphology is almost impossible [30].

Peeters & Claessens [18] have reported that left hand 2D:4D ratio does not predict performance in elite female gymnasts. Research indicates that flexibility may be influenced by the hormone relaxin which has a role in ligament laxity in females [31]. However a study which examined the levels of serum relaxin in athletic populations showed no significant difference between two sexes, but the links between relaxin levels and generalised joint laxity are limited [18,31].

In contrast to these results, Manning and Hill [24] have found that 2D:4D ratio of the right and left hand was negatively related to sprinting speed over 20 m, 30 m, 40 m and 50 m in a sample of teenage boys (girls were not considered). They suggested that 2D:4D is a relatively weak predictor of strength and a stronger predictor of efficiency in aerobic exercise [24]. Also, Fink et al (2003) stated that digit ratio is found to be significantly lower in men than in women [10]. Significant negative correlations were also found between female's left and right hand 2D:4D, waist and hip circumference, and WCR. In males, BMI was found to be positively related to digit ratio but remained significant only for left hand 2D:4D [10].

2D:4D ratio appears to be a marker of prenatal testosterone levels in humans, in which lower (and thus more male-like) values indicates higher levels of prenatal testosterone [19,24,32]. As 2D:4D ratio can be easily measured, it has become increasingly popular as a (putative) tool for studying effects of prenatal androgenisation in humans [24,32]. The 2D:4D is sexually dimorphic, showing lower mean values in males than in females. This dimorphism is determined in utero and appears by the 14th week of gestation. The 2D:4D ratio therefore likely reflects the prenatal hormonal environment for both males and females, and is unaffected by the hormonal changes of puberty [9,33].

In this regard, a study conducted by Hönekopp et. al. [6] showed that 2D:4D ratio is negatively related to scores of physical education of teenagers and the results of physical fitness tests in adults (including push-ups, repetitive jumping over more than one barrier, swimming, running, repetitive rope picking and repetitive ball throwing in basketball). Also, they suggest that aspects of sport and athletics mimic behaviors which are important in male–male fighting. Performance in these behaviors is important in the overall performance levels of many sports. They therefore suggest that our finding of a negative association between 2D:4D and physical fitness is best interpreted within an evolutionary framework of intra-sexual selection [6].

Ranson et. al. [17] indicate that in boys but not girls (aged 8–12 years), 2D:4D is significantly and negatively correlated with scores in 5 ×10 m sprints, the 20 m shuttle run and hand grip strength tests except the standing broad jump. In girls but not boys, 2D:4D is significantly and positively correlated with stature, mass, BMI and waist circumference. Also, the correlations between 2D:4D ratio and flexibility were not significant in boys or in girls. They suggested that 2D:4D can't predict those children's performance in sports which are involved with high flexibility. Ranson et al have reported significant links between 2D:4D and aerobic fitness in boys [17] and there has been a decline in the UK of aerobic fitness at a rate of 1.3% and 2.3% per year in boys and girls respectively from 1998-2010 [34]. It is likely that an increase in sedentary behaviour accounts for much of this decline. However, there may also be an influence on aerobic fitness via the developing foetus from the increasing use of endocrine distorters [17]. In addition, Zhao et al. [35] reported a significant and negative correlation between right hand 2D:4D ratio and handgrip strength in males but not in females. It is suggested that there is a potential stronger relationship between prenatal androgen exposure and the generation of muscular strength as well as cardiovascular system in males whereas such link is lacking in females [35]. Fink et al [36] reported that low 2D:4D was associated with high handgrip strength in German and Mizos men, and in Chinese men.

If talent detection in function of elite performance in particular sports is the aim of measuring digit ratios, future studies should consider testing children and adolescents for this alleged association, since talent detection for sports in adulthood makes no sense. In addition it recommended the relationship between the 2D:4D ratio and the health and physical fitness in post-puberty boys and girls and in the elite population and in men and women's lower levels sports.

CONCLUSSION

According to the results, it seems that 2D:4D ratio not a good indicator to predict the physical fitness in boys. Also, The results indicate measurement of digit ratio has no place in a talent detection programs for physical fitness and athletic abilities in boys. Future studies should investigate this claim in order to consider various other procedures for children.

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