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Relationship between 2d:4d ratio, handgrip strength, and hamstring muscle length in different sports: a study of volleyball, football and basketball branches

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: The relationship between the 2nd digit (2D) and the 4th digit (4D) provides much preliminary information about the physiological, psychological, and psychomotor characteristics of individuals. Although there are many studies on the 2D:4D ratio, the number of studies investigating the ratio in different sports is limited. Therefore, the purpose of this study is to determine the relationship between the 2D:4D ratio, posterior thigh muscle length, and handgrip strength in different sports.

Material and Methods: 63 athletes aged 18-29 years from football, volleyball and basketball participated in this study (n_{Futbol}=20, $n_{Voleybol}$=21, $n_{Basketbol}$=22). Right and left hand width and length, 2D, 4D, 2D:4D ratio, grip strength, and hamstring muscle length of the participants were determined. When examining the relationship between the parameters, hand grip strength and hamstring muscle length, Pearson correlation analysis was performed.

Results: In the study, there was a high correlation between right and left hand width, length, 2D, and 4D measurements and handgrip strength of volleyball and basketball players ($p<.05$). There was also a high correlation between left 2D:4D ratio in basketball players and handgrip strength ($p<.05$). There was a moderate correlation between football players' 2D length of the football players and the length of the hamstring muscle ($p<.05$). In volleyball and basketball branches, no parameter was associated with hamstring muscle length in volleyball and basketball players. Sport age and right hand 2D:4D ratio were associated in football ($p<.05$). For volleyball, athletic age was associated with left hand width and length and 2D and 4D measures ($p<.05$). In basketball, athletic age was associated with left hand width and length.

Conclusions: The results of the study suggest that some of the right and left hand measurements can be used to predict performance indicators such as hand grip and hamstring muscle length in the sports of football, volleyball, and basketball.

Keywords: Digit Ratio, 2D:4D, football, volleyball, basketball.

Introduction

The importance of physiological and physical fitness as well as talent and skill are increasing day by day in all sports. In the study of the studies, the number of studies dealing with the physical and physiological structure and focusing on scientific bases for different sports is increasing day by day [1, 2]. The ratio of the length of the second (index) finger to the fourth (ring) finger (2D:4D) is sexually dimorphic in humans. When samples from different populations were averaged, female values were found to be approximately 0.25 standard deviations higher than male values [3]

Several lines of evidence in the literature suggest that levels of fetal sex hormones (particularly androgens) reveal the sex difference in 2D:4D and that these measurements influence sex change [4]. Studies examining the difference in the 2D:4D ratio between the sexes indicate that this difference is due to a number of reasons [5, 6, 7]. Most studies in the literature suggest that in the prenatal period, estrogen hormone promotes growth of 2D and testosterone hormone promotes growth of 4D. Therefore, a low 2D:4D ratio reflects masculine traits with high testosterone-low estrogen levels in the prenatal period, whereas a high 2D:4D ratio reflects feminine traits with low testosterone-high estrogen levels [6].

The results of the study by Lutchmaya et al. revealed a negative correlation between 2D:4D and fetal testosterone/fetal estrogen, providing further evidence for the existence of an effect of prenatal sex steroids on finger development [8]. In formulating the length of the index finger on the human hand, three conditions can be proposed: the index finger is shorter than the ring finger (2D < 4D); the index finger is equal to the length of the ring finger (2D = 4D); and the index finger is longer than the ring finger (2D > 4D). In this formulation, the formula (2D < 4D) usually predominates in males

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and the formula (2D > 4D) usually predominates in females, although sometimes the situation 2D = 4D occurs. In other words, the short index finger gene is dominant in males and recessive in females [9]. The presumed relationship between 2D:4D and prenatal testosterone led Manning and Bundred to suggest that high athletic performance may be associated with low 2D:4D (Manning and Bundred, 2001). 2D:4D is a biomarker for performance in a variety of sports, athletic disciplines (e.g., middle and long distance running), and cardiovascular disease [10].

The 2D:4D ratio is commonly used in health, behavioural, and sports sciences as a putative indicator of prenatal testosterone exposure [11]. The hamstring muscle group is located at the back of the thigh and has a major influence on walking, balance, and coordination. The fact that the hamstring muscle is not of normal length, that is, has a negative effect on walking and training, especially in athletes [12, 13]. Examination of the literature reveals that the 2D:4D ratio is associated with many performance indicators. However, there are few studies that compare this relationship between different industries. For this reason, this study examined the relationship between the 2D:4D ratio of football, volleyball, and basketball players, and between hand grip strength and hamstring muscle length.

Material and Methods

Participants

In the power analysis conducted to determine the research sample, with a type I error (α) of 0.05 and a power (1-β) of 0.80 and an effect size of 1.4, it was determined that at least 50 participants should participate in the research [14]. In this context, in our research is included licenced active (at least 2 days per week) volleyball, football, and basketball players. Individuals with cardiovascular problems, chronic respiratory problems, psychological problems, surgical procedures that affect hand morphology, or with an implant in the hand area will not be included in the study. Participants who do not want to perform the tests during the study and do not comply with the working principles will be excluded from the study. In conclusion, 63 athletes aged 18-29 years from the football, volleyball and basketball teams of Bandırma Onyedi Eylul University participated in our study.

Collection of Data

After the athletes participating in the study signed the informed consent form, their demographic data were collected. The hand measurements (hand length, hand width, 2D length, 4D length) of the athletes were taken. Then, the hand grip strength and hamstring muscle length of the participants were measured.

Hand width: second and fifth kind. The distance between the metacarpophalangealis was measured with a caliper and expressed in cm.

Hand length: Radius Proc. The distance between the distal styloid and the longest fingertip was measured with a tape measure and expressed in cm.

The ratio of 2D and 4D measurements: The length of the second and fourth fingers was measured twice with a caliper and recorded in cm.

Handgrip Strength: Arms were held standing at the side with the hand dynamometer in hand, with the measuring portion of the dynamometer facing outward. While squeezing the dynamometer with maximum force, the best degree to apply twice for both hands was recorded in kilograms [15].

Hamstring Length (Sit -Reach Test): The Baseline® device (Cooper Institute/ YMCA, AAHPERD, New York, USA) was used for the test. Before the measurement, the subject was asked to place his heels on the test device in a long sitting position, and then he was asked to lie forward three times and warm up. After that, the subject's arm length on the device was determined, and he was asked to stretch forward as far as possible by pressing on the measuring device with his fingertips without lifting his knees. The measurements were taken 3 times and the average was recorded [16].

Height Measurement: In height measurement, the participant's feet were bare, heels were together, and the body and head were measured and recorded. The movable part of the stadiometer was brought to the top of the head, the hair was sufficiently compressed, and the measurement was recorded to the nearest 1 mm. During the measurement, participants were asked to breathe deeply and maintain their upright position [17].

Weight Measurement: It was measured with an electronic scale of SECA brand (Germany) with an accuracy of 0.1 kg, and the participants' feet were bare and they wore shorts and T-shirts during the measurement [17].

Ethical Dimension of Research

'Voluntary Consent Form' was obtained from all participants. Participants were informed of the tests to be performed. Participants were informed that participation in the study was on a voluntary basis and that they could withdraw from the study at any time. The study was conducted in accordance with the principles of the Declaration of Helsinki. The necessary permissions were obtained with the approval of the Ethics Committee of the Institute of Health Sciences of Bandırma Onyedi Eylul University and resolution number 2022/171 to conduct the study.

Statistical analysis

SPSS package program 25 was used for statistical analysis of the research. Normality analyzes of the data were determined according to Skewness and Kurtosis values (+1.5/-1.5). It was found that

the data were not normally distributed. Pearson Correlation analysis was performed to determine the relationship between the data [18]. The level of significance in the study was determined as 0.05.

Results

When Table 1, is examined; average age of football players = 20.92 ± 1.93 years, average height = 179.46 ± 6.15 cm, average body weight = 72.69 ± 9.08 kg, average BMI = 22.50 ± 1.85 kg / m2, average sport age = 8.69 ± 1.93 years. The average age of volleyball players = 21.23 ± 2.62 years, the average height = 175.19 ± 9.96 cm, the average body weight = 66.57 ± 11.4 kg, the average BMI = 21.54 ± 2.03 kg / m2, the average sport age = 4.61 ±.4.56 years. The average age of basketball players was determined as 19.68 ± 1.35 years, their average height = 176.13 ± 13.18 cm, their average body weight = 68.16 ± 14.55 kg, their average BMI = 21.76 ± 2.50 kg / m2, the average age of sport = 6.27 ±.3.90 years.

When Table 2 was examined, a high correlation was found between right hand width, right hand length, right 2D length, and right 4D length and grip strength in volleyball and basketball ($p< 0.05$), while no correlation was found in football ($p > 0.05$). While there was a moderate negative correlation between 2D right hand length and hamstring length in football, no significant difference was found between right hand measurements and hamstring length in all branches ($p > 0.05$).

When Table 3 was examined, a high correlation was found between left hand width, left hand length, left 2D length, and left 4D length in volleyball and basketball branches and handgrip strength ($p< 0.05$), whereas no correlation was found in football ($p > 0.05$). There was no significant difference between right hand and hamstring length measurements in all areas ($p > 0.05$). It was found that the 2D:4D ratio of the left hand was crucial for the handgrip and hamstring length in basketball branch ($p< 0.05$).

Table 1. Descriptive Information of Participants

Parameters	**Football (n:20) (13 male, 9 female) X̄±SD**	**Volleyball (n=21) (9 male, 12 female) X̄±SD**	**Basketball (n:22) (11 male, 11 female) X̄±SD**
Age (year)	20.92 ± 1.93	21.23 ± 2.62	19.68 ±1.35
Height (cm)	179.46 ± 6.15	175.19 ± 9.96	176.13 ± 13.18
Weight (kg)	72.69 ± 9.08	66.57 ± 11.4	68.16 ± 14.55
BMI (kg/m^2)	22.50 ± 1.85	21.54 ± 2.03	21.76 ± 2.50
Sport Age (year)	8.69 ± 1.93	4.61 ±.4.56	6.27 ±.3.90

Table 2. The Relationship between Participants' Right Hand Parameters and Hand Grip Strength and Hamstring Length

Parameters	**Branch**	**X±SD**	**Handgrip Strength**	**Hamstring Length**
Right Hand Width (mm)	Football	88.02±2.19	r= .147, p= .632	r= -.191, p= .532
	Volleyball	84.61±6.04	r= .927, p= .000**	r= -.103, p= .658
	Basketball	85.41±6.14	r= .828, p= .000**	r= -140, p= .533
Right Hand Length (mm)	Football	193.43±6.83	r= .267, p= .379	r= -.524, p= .066
	Volleyball	185.52±10.17	r= .738, p= .000**	r= -171, p= .458
	Basketball	184.94±12.69	r= .724, p= .000**	r= -.170, p= .449
Right 2D (mm)	Football	74.70±4.18	r= .013, p= .967	r= -.573, p= .041*
	Volleyball	72.66±5.03	r= .789, p= .000**	r= -.195, p= .397
	Basketball	72.06±5.36	r= .624, p= .002**	r= -.040, p= .859
Right 4D (mm)	Football	74.98±3.83	r= .183, p= .550	r= -.546, p= .118
	Volleyball	73.65±5.22	r= .633, p= .002**	r= -.053, p= .820
	Basketball	72.30±5.26	r= .719, p= .000**	r= .-150, p= .506
Right 2D:4D (mm)	Football	0.99±0.02	r= -.346, p= .247	r= -.346, p= .246
	Volleyball	0.98±0.03	r= .280, p= .218	r= -.278, p= .223
	Basketball	0.99±0.02	r= -.202, p= .368	r= .289, p= .192

*Modarate corelation between parameters, **High-level corelation between parameters

When Table 4 is examined, a moderate inverse relationship between sport age in football and the 2D:4D ratio of the right hand (p< 0.05). In volleyball players, a high association was found between sport age and right hand width and a moderate association between right hand length and right 2D length. (p< 0.05). Among basketball players, a moderate correlation was found between right hand length and sport age in basketball players (p< 0.05).

When Table 5 was examined, it was found that there was no significant correlation between athletic age and left hand parameters in football (p > 0.05). In volleyball, a high correlation was found between sport age and left hand width and left 4D lengths,

Table 3. The Relationship between the Hand Grip Strength and Hamstring Length of the Left Hand Parameters of the Participants

Parameters	Branch	X±SD	Handgrip Strength	Hamstring Length
Left Hand Width (mm)	Football	85.79±4.05	r= .303, p= .313	r= -.320, p= .286
	Volleyball	82.99±5.95	r= .826, p= .000**	r= -.080, p= .751
	Basketball	84.52±5.96	r= .844, p= .000**	r= -166, p= .460
Left Hand Length (mm)	Football	186.10±24.95	r= -.002, p= .994	r= .254, p= .401
	Volleyball	185.57±10.02	r= .807, p= .000**	r= -149, p= .519
	Basketball	185.15±12.74	r= .705, p= .000**	r= -.186, p= .407
Left 2D (mm)	Football	73.91±4.04	r= .043, p= .888	r= -.454, p= .119
	Volleyball	72.74±5.68	r= .685, p= .001**	r= -.212, p= .356
	Basketball	72.15±4.89	r= .674, p= .001**	r= -.087, p= .701
Left 4D (mm)	Football	74.56±3.77	r= .096, p= .755	r= -.465, p= .109
	Volleyball	73.62±5.98	r= .823, p= .000**	r= -.330, p= .143
	Basketball	72.44±5.52	r= .766, p= .000**	r= .-228, p= .308
Left 2D:4D (mm)	Football	0.99±0.02	r= -.110, p= .721	r= -.049, p= .873
	Volleyball	0.98±0.04	r= -.317, p= .162	r= .229, p= .319
	Basketball	0.99±0.02	r= -.536, p= .010**	r= .438, p= .042*

*Modarate corelation between parameters, **High-level corelation between parameters

Table 4. The Relationship Between Sports Age and Right Hand Parameters

Parameters	Branches	Right Hand Width	Right Hand Length	Right 2D	Right 4D	Right 2D:4D
Sport Age	Football	r= .106,	r= .225	r=.208	r= .500	r= -.575
		p= .730	p=.460	p= .496	p= .082	P= .040*
	Volleyball	r= -.636	r= -.463	r= -.488	r= -.368	r= -.238
		p= .002**	p=.035*	p= .025*	p= .101	P= .298
	Basketball	r= .395	r= .503	r= .343	r= .339	r= .048
		p= .069	p=.017*	p= .118	p= .122	P= .833

*Modarate corelation between parameters, **High-level corelation between parameters

Table 5. The Relationship Between Sports Age and Left Hand Parameters

Parameters	Branches	Left Hand Width	Left Hand Length	Left 2D	Left 4D	Left 2D:4D
Sport Age	Football	r= .093	r= -.180	r= .152	r= .407	r= -.541
		p= .762	p= .556	p= .620	p= .168	P= .056
	Volleyball	r= -.588	r= -.527	r= -.511	r= -.551	r= .113
		p= .005**	p=.014*	p= .018*	p= .010**	P= .626
	Basketball	r= .469	r= .465	r= .434	r= .419	r= -.131
		p= .028*	p=.029*	p= .044	p= .052	P= .560

*Modarate corelation between parameters, **High-level corelation between parameters

and a moderate correlation was found for left hand length and left 2D lengths ($p< 0.05$). In basketball, a moderate correlation was found between sport age and left hand width and left hand length ($p< 0.05$).

Discussion

This study investigated the effect of 2D:4D ratio on grip strength and hamstring muscle length in football, volleyball, and basketball players. The length, width, 2D, 4D, and 2D:4D ratio of both hands of the athletes were examined. The 2D:4D ratio allows us to have an idea about many performance indicators [19]. As a result of our study, a high relationship was found between right hand width, right hand length, right 2D length, and right 4D length and handgrip strength in the sports of volleyball and basketball; a high relationship was found between left hand width, left hand length, left 2D length, and left 4D length and handgrip strength in volleyball and basketball. A moderate negative correlation was found between right hand 2D length and hamstring length in football.

It is known that the 2D:4D ratio is lower in women than in men [20]. It has been suggested that the reason for this is the effect of prenatal testosterone on the 4D ratio [21]. In this case, it is common for males to have a lower 2D:4D ratio than females. In our study, the 2D:4D ratio of females was higher than that of males in all branches.

For many years, many studies have shown that there is a negative relationship between 2D:4D ratio and performance indicators such as rugby, surfing, rowing, sprinting, and endurance [21, 22, 23]. In addition, there may be differences between right and left hand 2D:4D performance levels. For example, a lower 2D:4D ratio of the right hand in men means a better representation of aerobic abilities [24]. This is because the right finger ratio is more sensitive to prenatal sex steroids than the left finger ratio [10]. In our study, a relationship was found between the 2D:4D ratio and handgrip strength and hamstring length in different hands in different branches. We hypothesise that the reason for this lies in the differences in structure and performance requirements of the sports of football, volleyball, and basketball.

In a study conducted by Manning and Taylor, it was shown that men with a low 2D:4D ratio are more successful in many sports and have better balance and coordination, which is another positive trait in sports [25]. In our study, we found that the 4D ratio was high in both the right and left hands of football players. Therefore, it can be concluded that some performance indicators are better in football players than in volleyball and basketball players.

Hand strength is one of the most important factors for athletic success, especially in volleyball players. Studies have reported that 2D:4D ratio has a negative relationship with right-left hand strength [26]. When the results of our research were examined, it was found that there were similar results to those reported in the literature. Also, hamstring muscles are important muscle groups that provide balance and coordination of the lower extremities (Arıcı & Elhan, 2014). We could not find any study in the literature that investigates the relationship between the 2D:4D ratio and the hamstring muscles. In this context, our study will contribute to the literature. In our study, we found a negative relationship with 2D:4D ratio on the right side in football and volleyball players and on the left side in football players.

Conclusions

According to the results of our study, a significant relationship was found between measurements of hand length, 2D and 4D length, and hand grip strength in volleyball and basketball sports. Athletic age significantly influenced hand length measurements in all sports. In addition, a relationship was found between the 2D:4D ratio of the left hand and grip strength and posterior thigh muscle length in basketball. It was also found that there was a moderate relationship between sport age and 2D:4D ratio in football. Considering all these results, it was found that 2D:4D ratio affects grip strength in different sports, but not posterior thigh muscle length. For this reason, it is considered that the determination of hand length and 2D:4D ratio in the sports of football, volleyball, and basketball, especially in the skill selection phase, will be a guide for estimating the performance level of athletes. There are many studies in the literature on which performance indicators the 2D:4D ratio provides effective results. It can also be recommended to conduct research to determine the relationship between performance indicators and the 2D:4D ratio, which are important in football, volleyball and basketball. It is assumed that the 2D:4D ratio can be used in the selection of sports.

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Conflicts of Interest

The authors declare no conflict of interest.

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