

2D:4D Ratio as a Predictor for Swimming Learning- A Pilot Study

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ABSTRACT

Introduction: Competitive swimming is one of the popular sports, where physical conditioning and skill have a large contribution in achieving high-level performances. In males, the second to fourth digit ratio (2D:4D) have lower values than females but the mean digit ratio remains the same with age. This ratio is considered to be a biomarker of the balance between Foetal Testosterone (FT) and Foetal Oestrogen in a nearly embryonic stage.

Aim: To determine the correlation of 2D:4D ratio in swimming beginners.

Materials and Methods: This cross-sectional pilot study was conducted in the swimming pool facility of Banaras Hindu University Varanasi, Uttar Pradesh, India from March 2019 to June 2019. A total of 118 (59 females and 59 males), swimming beginners participants having age between 18 to 27 years were selected and cross-sectional samples were taken for the study. Participants passed all the stages of swimming learning under a well-trained coach for six weeks. In the last week of swimming learning, final performance assessment tests were conducted. For which six minutes was given to each participant and the total distance covered during swimming was measured in meters. Body Mass Index (BMI) was calculated from measured height

and weight. The left and right 2D:4D ratio, height and length of participants were recorded and analysed for correlation. The collected data were analysed using a Statistical Package for the Social Sciences (SPSS), 16.0 version.

Results: A total of 118 participants, 59 males and 59 females, with mean age of the male participants was 21.37 ± 3.52 years and the mean age of the female participants was 20.64 ± 2.63 years. The mean 2D:4D ratio of both right and left hand digits in both sexes was <1 . In males, the right hand 2D:4D ratio was negatively correlated ($r = -0.444$) with swimming learning performance and it was found significant (p -value = 0.004) but the left hand 2D:4D ratio was negatively correlated ($r = -0.176$) which was not significant with swimming learning performance. In female's right hand, the 2D:4D ratio and BMI were negatively correlated which was not significant with swimming learning performance ($r = -0.095$, $r = -0.018$, respectively).

Conclusion: The study shows a significant 2D:4D ratio correlation with swimming learning performance in males right hand. So, 2D:4D ratios can be used as reliable criteria as a predictor of swimming learning and swimmer's competitive performance however, it needs further extensive study.

Keywords: Endurance, Foetal oestrogen, Foetal testosterone, Muscle strength

INTRODUCTION

Competitive swimming is one of the popular sports which need to be widely researched. It is a complex individual sport that requires good physical condition and muscular strength to achieve high-level performances. The aquatic environment presents various challenges for humans so researchers are also interested to have deep insight into human performance in the water. No doubt there are so many physiological, biochemical and anthropometrical determinant factors about swimming learning and its higher performance [1].

A 2D:4D ratio is the ratio of second to fourth digit length. Males have a lower digit ratio (longer fourth digits relative to second digits) than females but the mean digit ratio did remain the same with age. This ratio is considered one of the biomarkers of the balance between FT and FE in an early embryonic stage [2]. Lots of researchers showed negative relationships between digit ratio and sports performance like rugby, surfing, rowing, sprinting, endurance, and handgrip strength [1,3-6]. It is known that the digit ratio of neonates was related to a balance of FT and FE. The difference in digit ratio in fetuses is found as early as the end of the first trimester. This supports that FT levels are sexually dimorphic, that is, male fetuses have higher testosterone than female fetuses. So, the prenatal determination of the sexual dimorphism in digit ratio represents that the sex difference in digit ratio reflects levels of prenatal sex steroids [7-9].

Previous research papers showed the relationship between low digit ratio and marked sudden surge of testosterone in the competitive sport after the end of the competition. The low digit ratio is also linked to high levels of performance in females. These correlations explain the link between low digit ratio and competitive sports [10]. Several studies showed that the digit ratio is related to a wide range of psychological characteristics like alcoholism, attention-deficit disorder, eating disorder, fertility, myocardial infarction, assertiveness and aggression, the onset of menarche, homosexuality, and depression [11-21]. Muscle strength and endurance are the foremost important factors for swimming performance. Though, swimming performance is affected by the swimmer's technique and his or her movement abilities. However, to the best of our knowledge, no updated research on the 2D:4D ratio as a predictor of swimming learning. Therefore, a pilot study was conducted with an aim to determine the correlation of 2D:4D ratio in swimming beginners or learners.

MATERIALS AND METHODS

This cross-sectional pilot study was conducted in the swimming pool facility of Banaras Hindu University with the official permission of the University Sports Board of Banaras Hindu University, Varanasi Uttar Pradesh, India from March 2019 to June 2019. Institutional Ethics Committee approval was obtained before conducting the study. (IEC No.- Dean/2018/EC/937).

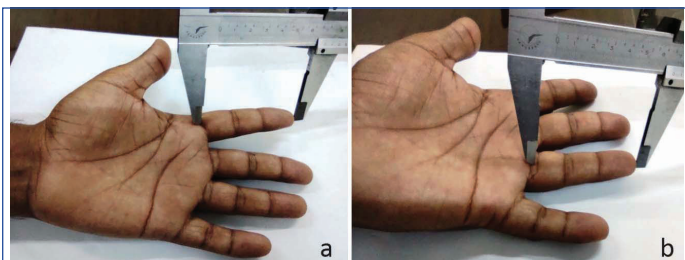
Inclusion criteria: Swimming learners between age between 18-27 years were included in the study.

Exclusion criteria: Swimming learners below 18 years of age and above 27 years were excluded from the study.

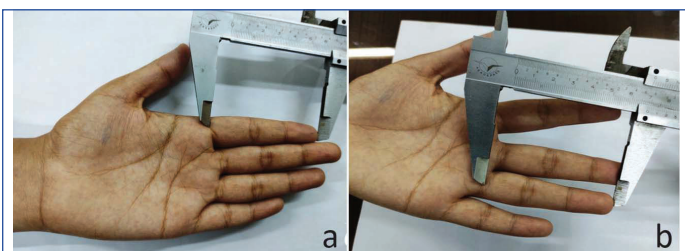
Out of the total enrolled members for swimming learning in the University swimming pool, randomly 118 members (59 females and 59 males), ranging in the age group from 18 to 27 years were selected for the study. The detailed information about the study has been given to the participants and the University Sports Board authorities. Participants passed all the stages of swimming learning like relieving anxiety, water fear, muscle strengthening exercises, breathing exercises, water floating, under a well-trained coach for six weeks. At the end of every week assessment test was done for learning and adaptation to the aquatic environment. Last week final performance assessment test for swimming learning was conducted. For which, six minutes was given to each participant and recorded total swimming distance in meters.

Anthropometric Measurements

A Holtain brand anthropometric set was used for the measurements. The weights of the swimmers were measured using a digital bascule with a 0.1 kg of sensitivity and their heights were measured with a stadiometer with a 0.01 m of sensitivity and the Body Mass Index (BMI) was calculated using the body mass (kg)/height (m²) formula. Finger lengths were measured using a vernier caliper that can measure upto 0.05 mm between the proximal skin crease and the tip of the 2nd finger (index finger) and the 4th finger (ring finger) on the palm of their right hands. The measurements were carried out by the same person twice for accuracy and they were noted down in millimeters (mm) [Table/Fig-1,2].



[Table/Fig-1]: a) Shows taking measurements of 2D (index finger); and b) Shows taking measurements of 4D (ring finger) in males.



[Table/Fig-2]: a) Shows taking measurements of 2D (index finger); and b) Shows taking measurements of 4D (ring finger) in females.

Before taking the measurements, each subject was asked to remove the shoes. The measurements were taken by one observer to avoid an interobserver error. The measurements were taken using standard anthropometric instruments according to the techniques described by Vallois HV [22].

The subjects included in the study were healthy and free from any apparent symptomatic deformity. All the measurements were taken at the university evening batch swimming learning time between 5:30 pm to 6:30 pm.

STATISTICAL ANALYSIS

The collected data were analysed using a Statistical Package for the Social Sciences 16.0 version (SPSS 16.0). The mean and standard deviations of all data have been calculated. To determine if the statistical relationship between anthropometrical characteristics and swimming performance, the Pearson's Correlation Coefficient was analysed to reach the best estimate possible. A p-value <0.05 considered statistically significant.

RESULTS

A total of 118 participants who voluntarily participated in the study were 59 males and 59 females swimming beginners group. The mean age of the male participants was 21.37±3.52 years, mean height was 169.73±6.99 cm, and mean weight was 62.97±12.25 kg. The mean age of the female participants was 20.64±2.63 years, mean height was 156.36±8.27 cm, and mean weight was 54.92±7.81 kg. Body Mass Index (BMI) was calculated in both sexes from measured parameters [Table/Fig-3].

The mean value of the 2D:4D ratio of both hands in males as well as females was less than one. In Males, the right hand 2D:4D ratio was negatively correlated ($r=-0.444$) with swimming learning performance and also it was statistically significant ($p\text{-value}=0.004$) [Table/Fig-4] but the left hand 2D:4D ratio though it was negatively correlated ($r=-0.176$) and not significant. Values of BMI are neither statistically significant nor showing correlation with the 2D:4D ratio and swimming learning performance. Interestingly, in female participants in right hand, both 2D:4D ratio and BMI negatively correlated with swimming learning performance ($r=-0.095$, $r=-0.018$, respectively) but both were statistically not significant however 2D:4D ratio of the left hand of females showed a negative correlation which was not significant statistically [Table/Fig-4].

DISCUSSION

The present study highlighted the issue by examining relationships between the digit ratio (2D:4D) and swimming learning performance in young swimming learners and comparative analysis in males and females. Previous researches revealed that there is a negative correlation between digit ratio and

Gender	Statistical parameters	Age (years)	Weight (kg)	Height (cm)	Body mass index (kg/m ²)	RH 2D	RH 4D	RH 2D/4D ratio	LH 2D	LH 4D	LH 2D/4D ratio	Swimming performance (Distance in meters)
Male (n=59)	Mean	21.37	62.97	169.73	21.830	72.659	73.626	0.987	72.700	74.098	0.982	32.1
	Median	20	62	169	21.050	72.020	73.960	0.978	73.090	74.400	0.977	34
	Standard deviation	3.528	12.255	6.995	4.010	5.823	5.475	0.033	5.261	6.140	0.028	8.047
	Minimum	18	42	158	15.808	61.690	62.620	0.915	61.700	61.060	0.914	20
	Maximum	33	90	187	33.058	89.620	88.070	1.076	89.890	91.880	1.057	50
Female (n=59)	Mean	20.64	54.92	156.36	22.614	64.783	65.628	0.988	65.283	65.866	0.992	28.16
	Median	20	54	157	21.641	64.230	64.900	0.989	64.260	65.520	0.996	30
	Standard deviation	2.638	7.811	8.275	3.963	4.181	4.473	0.027	3.853	4.183	0.029	8.33
	Minimum	18	41	105	17.066	58.000	58.950	0.933	58.500	58.950	0.920	15
	Maximum	27	78	168	40.816	74.270	75.650	1.075	72.570	77.000	1.058	45

[Table/Fig-3]: Various parameters of study subjects.

LH: Left hand; RH: Right hand

Gender	Ratio	p-value (p) and correlation coefficient (r)	Swimming performance (Distance in meters)	Body mass index (kg/m ²)
Male	Right hand 2D/4D ratio	p	0.004*	0.536
		r	-0.444	0.082
	Left hand 2D/4D ratio	p	0.182	0.047
		r	-0.176	0.259
	Swimming performance (Distance in meters)	p	-	0.880
		r	1.000	0.019
Female	Right hand 2D/4D ratio	p	0.467	0.886
		r	-0.095	-0.018
	Left hand 2D/4D ratio	p	0.460	0.071
		r	-0.097	0.234
	Swimming performance (Distance in meters)	p	-	0.174
		r	1.000	-0.177

[Table/Fig-4]: Correlation of swimming performance, 2D/4D ratio and BMI in male and female participants.

*p-value<0.05 was considered as statistically significant

prenatal testosterone, but a positive correlation with oestrogen exposure [5,23]. It is a known fact that a low 2D:4D ratio is linked with a higher level of testosterone [5]. The importance of testosterone hormone for the accrual of muscle mass or strength is indicated by several studies. In this connection, much of the research investigating the links between digit ratios and athletic performance has reported that elite athletes have a low 2D:4D ratio [24].

It is difficult to compare the present results to previous studies because the results of all these studies are different from each other and it is assumed that the differences stem from the number of the subjects, their age, and varieties of exercises. Previous studies had mostly focused on athlete's performance in different competitive sport but the present study was specifically focused on learning swimming skills and comparative performance among male-female participants [10]. However, authors tried to compare and correlate the present study results to previous work. The work of Bennett M et al., was performed to examine the relationship between 2D:4D and performance in elite rugby players had shown that low right 2D:4D and low right-left 2D:4D ratio difference were the predictors of high rugby performance [3].

Results of Longman D et al. in 2011 study showed significant negative correlations of rowing player's ergometer performance and male digit ratios. This indicates that digit ratio is a predictor of ability in rowing, a sport that requires both cardiovascular efficiency and high power output in males [5]. Honekopp J et al., study strongly supports our results as a strong correlation was found in late adolescent girl's physical education grades and right ($r=20.17$) and left ($r=20.16$) hand digit ratios [19]. The present study disagrees with the results of Fink B et al., regarding BMI correlation with 2D:4D ratio in females which showed no significant relationship between body mass index and 2D:4D ratio but our result showed strong negative correlation ($r=-0.177$) this may be due to sampling size [18].

Limitation(s)

As all the measurements were taken directly with vernier caliper and authors did not take parallel measurements with other techniques like X-ray, DXA scan to avoid errors. There would be chances of errors during measurements taken in water in the 50 meter swimming pool.

CONCLUSION(S)

A 2D:4D ratios can be used as reliable criteria as a predictor of swimming learners (beginners) as well as competitive swimmer's

performance however it needs further extensive study with overcoming possible limitations.

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