Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 11 (1)

Relationship between Second Digit Length, Fourth Digit Length and Ratio (2D:4D) and Selected Sport Groups in Ilorin Metropolis

Alabi, AS, Daramola OC; Kareem SB, Lewu FS, Adigun FM and Alabi A
Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, University of Ilorin, Kwara State, Nigeria

Corresponding Author: Alabi AS
E-mail:dradealabi@gmail.com; +2348030575490.

ABSTRACT
This study aimed at determining the anthropometric measurements of the second digit length, fourth digit length and second to fourth digit ratio of individuals in selected sport groups in Ilorin metropolis. It was carried out by measuring the digit length of 350 volunteers consisting of 175 males and 175 female hand-sports participants (i.e. Basketball, Volleyball, Table tennis, Lawn tennis and Badminton) non-hand sport participants(i.e. Football, Athletics, Aerobics and Martial arts) and non-sport participants within the ages of 18 to 65 years. Standard measurement processes were observed to obtain accurate digit length using the Digital Vernier Caliper. The data obtained was analyzed using statistical package for social sciences (SPSS Version 23, Armonk, USA).The results showed that digit ratio is an effective tool for distinguishing male sport participants from non-participants but it is not as effective for the female participants. It also showed that notable differences exist between the individuals that participate in hand-related sports and those who participate in other sports generally. The findings of this study suggest that second and fourth digit lengths and ratios can be adapted as sufficient markers for ascertaining an individual's sporting tendencies for various sport types.

Key words: Sport, Hand-sport, non-sport participants, Digit Ratio, Digit Lengths, Ilorin.

INTRODUCTIONThe earliest reference to 2D:4D ratio was made by researcher Manning and his coauthors in 1998. Specifically, it was proposed that under the influence of prenatal testosterone, growth of the lateral fingers (specifically, of 4D) is more promoted than growth of the medial fingers (specifically, of 2D) [1]. Following their discovery in the late 1990's, a number of authors have reported correlation between second to fourth digit ratio and several variables like ethnic diversity, as well as between 2D:4D and gender and testosterone level. It was found that females have longer second digit as compared to the fourth digit and higher 2D:4D, while the reverse is the case for males [2].

The ratio of second- to fourth digit lengths (2D:4D) has been in use in scientific literature for quite some time as a morphological indicator of fetal intrauterine prenatal testosterone (PT) and prenatal estrogen (PE) exposure, particularly, in humans [3]. Prenatal testosterone has been said to elongate the ring finger, whereas prenatal estrogen (PE) lengthens the index finger[4]. A relatively lower 2D:4D (implying a longer 4D and a shorter 2D) is indicative of higher PT exposure which is more common amongst males while higher 2D:4D ratio (implying a longer 2D and shorter 4D) is indicative of higher PE exposure as seen in most females. This ratio is determined by the proportion of PT and PE in a narrow window period of fetal development [3].

Further evidence that androgens are major contributors to the sex differences in athletic performance can be gotten from the fact that anabolic steroids are used to enhance athletic performance [5]. Athletic prowess in both males and females, as indicated by their performance on tests of physical skills and level of athletic achievement is associated with smaller 2D:4D [6]. The relationship between 2D:4D and athletic prowess may also be mediated by the effects of prenatal testosterone exposure on the cardiovascular system[7].

As a result of the vast importance of the second and fourth digit length and ratio, several research works have been aimed at investigating the association between digit ratio and variables like musical abilities [1], sport/athletic abilities[2], penile length, risk for obesity [8], autism, sexual orientation [9], etc. Most commonly, as regards athletic abilities, several literatures have been published and it could be said that professional players have a significantly lower 2D: 4D (derived from left and right 2D: 4D) compared with controls, indicating longer 4D lengths [2].

Speculations have been made and investigations have been carried out to observe the correlation between 2D:4D, Visuos patial ability [10], hand grip strength [6] and risk taking ability [3] which would be a benefit while playing sports that involve projectiles (tennis, badminton, golf etc.), overhand throwing (volleyball, handball, soft ball, etc.) and certain contact sports (basketball).Low 2D:4D has also been reported to be associated with faster skiing speed on a timed downhill slalom run, even after the effects of sex, age and skiing experience were removed [6]. In a recent meta-analysis, medium- and long duration running showed the strongest relationships between 2D:4D and physical performance, whereas, team based field sports (e.g., rugby and football) and other individual sports (e.g., skiing, fencing) did exhibit relatively smaller associations [3].

Although considerable variability exists across different activities, subsequent research has shown that people with low digit ratios tend to be better at gridiron, basketball, fencing, handball, rugby, running, skiing, swimming, tennis and volleyball [11].

Frick et al.[12] carried out a study investigating the relationships between 2D:4D and competitive Basketball performance in Australian men. It was discovered that significant differences exist between competitive standards for the left 2D:4D but not for the right 2D:4D, with Basketballers who achieved higher competitive standards tending to have lower 2D:4Ds.

Most of the sport related studies with 2D:4D dealt with its associations with physical ability, endurance and sporting prowess. However, all these studies compared 2D:4D, either between performers and non-performers [10] or between high and low ranking performers within specific sport discipline [12].

This study is aimed at investigating 2D:4D and its association with the type of sport, paying close attention to hand related sports (e.g. Basketball, Volleyball, Badminton, Table Tennis and Lawn Tennis) among male and female participants. It is hypothesized that people with relatively lower 2D:4D tend to have better visual-spatial and cognitive ability which is important in sports where athletes have to follow the flight of the ball, read the play and make tactical decisions [3]. More so, as a result of the digit length, recent studies show that those with lower ratios had better hand-grip strength than those with higher ratios [6]. Hence at the end of this study, it is expected that the digit ratio of those participating in hands sports should be relatively lower than other sports group and the control group (either male or female).

MATERIALS AND METHODS

This study involved a total of 350 volunteers (males and females) comprising of three categories; 150 individuals that participate in hand sports exclusively (i.e. volleyball, basketball, badminton, table tennis and lawn tennis), 100 individuals that belong to other sport groups (football, aerobics and martial arts) and 100 non-sports participants. Electronic digital caliper (that reads values to the nearest 0.01mm) was used to measure the subjects' right and left digit lengths. The digit length is the distance from the tip of the finger to the most proximal metacarpophalangeal crease.The players were asked to sign informed consent forms that validate their participation and fill questionnaires which contained information concerning their age in years, sex, specific sports they engage in and any known history of palmar deformity. This helped in separating the volunteers into various categories.The data was analyzed using statistical package for social sciences (SPSS Version 23, Armonk, USA).The data were described as mean (S.D) for all continuous variables. The inferential statistics was achieved using unpaired t-test for sex differences and Post Hoc (Dunnett T3) for multiple grouped variables (the different sport groups). All analysis were carried out at 95% confidence level; with p<0.05 taken to be significant.

RESULTS

The data of all volunteers involved in the study grouped is represented in Table 1. According to the table, classification of all subjects based on sex, age, right second digit (R-2D), right fourth digit (R-4D), left second digit (L-2D), left fourth digit (L-4D), right digit ratio (R-2D:4D) and left digit ratio (L-2D:4D) are shown.

The comparison between males and females of the three groups in Table 1 showed that for the non-sports group, females (73.19±4.35cm) had significantly greater right 2D than males (73.19±4.35cm) (t=-2.884, P=0.005), left 2D (F; 72.85±4.12cm, M; 70.72±3.97cm) (t= -2.638, P=0.01), and right and left 2D:4D ratios (R; t=-3.559, P=0.001, L; t=-2.788, P=0.006).

For the Non-hands sports group, males (77.65±5.61) had significantly greater right 2D than females (69.25±3.46), right 4D (M; 79.95±5.62 F; 68.81±4.20), left 2D (M; 77.82±5.87 F; 68.57±3.57), left 4D (M; 80.36±5.41 F;). However, females recorded significantly higher right and left digit ratios (R; t=*5.806* P=*0.001*. L; t=*6.151* P=*0.001*).

For the Hand sports group, the males (78.99±5.74) recorded significantly greater right 4D than females (75.31±4.53) and left 4D (M; 78.86±5.76 F; 68. 74.87±4.23) as well. However, females recorded significantly higher right digit ratios (R; t=*9.303* P=*0.001*).

In Table 2, the comparison between male who do not participate in sports and the general sports group showed that the sports had higher mean right 2D values (t=-7.351, P<0.001), right 4D (t=-9.947, P<0.001), left 2D (t=-8.981, P<0.001), left 4D (t=-10.823, P<0.001). However, the right ratio was not significantly different (t=-0.011, P=0.991) but the left 2D:4D ratios recorded significant difference (t=2.255, P=0.025).

Table 3 displays the comparison between female non-sports and sports participants. It shows that there is little or no significant difference between the mean values of the right 2D (t= 0.655, P=0.513), right 4D (t= 0.303, P=0.736), left 2D (t= 0.374, P= 0.709), left 4D (t= 0.827, P= 0.410), Right 2D:4D ratios (t=1.324, P= 0.188) and Left 2D:4D ratios (t= 0.220, P= 0.826).

The analysis of variance of the measured parameters of the male of the different groups presented in Table 4a showed that there was a significant difference in the right 2D, right 4D, left 2D, left 4D and left 2D:4D ratio (p<0.05); however, the right 2D:4D ratio was not statistically significant (p=0.764).In Table 4b, the mean values for the right 2D, right 4D, left2D and left 4D of those that did not participate in sports was significantly greater than non-hand sports and hand sports participants (p<0.001), but no difference was observed between the variables of non-hand sport and hand sports participants. No significant difference was recorded in the right and left digit ratios between non-sports group, non-hand sports group and hand sport group.

Table 5a shows the analysis of variance of the measured parameters of the female of the different groups presented. It can be observed that there was a significant difference in the right 2D, right 4D, left 2D, left 4D and right 2D:4D ratio (p<0.001); however, the left 2D:4D ratio was not statistically significant (P=0.929).

In Table 5b, significant differences were seen in the mean values for the right 2D, right 4D and left 4D variables between the female; non-sport participants, the non-hand sports and hand sports participants (p<0.001), as well as between the variables of non-hand sport and hand sports participants. No significant difference was recorded in the left 2D of the non-hand sports and general sports category as well as the right and left digit ratios of non- sports group, non-hand sports group and hand sport group.

Table 1: The descriptive characteristics and test of mean differences in 2D, 4D length and ratios of males and females that do not participate in sports (control) and those that participate in hand sport and non-hand sport.

Variables	Non - sports			Non - hand sports			Hand sports		
	Mean±S. D		T-test	Mean±S. D		T-test	Mean±S. D		T-test
	M (N=50)	F (N=50)	t-value (Sig)	M (N=50)	F (N=50)	t-value (Sig)	M (N=75)	F (N=75)	t-value (Sig)
Age (yrs)	23.70±5.60	22.92±4.85	N/A	22.00±2.93	23.4±3.53	N/A	23.88±5.58	21.61±3.67	N/A
R-2D (cm)	70.19±5.92	73.19±4.35	*-2.884 (0.005)*	77.65±5.61	69.25±3.46	*9.022 (<0.001)*	77.23±5.79	76.7±5.39	0.577 (0.565)
R-4D (cm)	71.93±3.87	2.48±4.12	-0.686 (0.495)	79.95±5.62	68.81±4.20	*11.221 (<0.001)*	78.99±5.74	75.31±4.53	*4.354 (<0.001)*
L-2D (cm)	70.72±3.97	2.85±4.12	*-2.638 (0.01)*	77.82±5.87	68.57±3.57	*9.511 (<0.001)*	77.28±5.50	75.11±9.91	1.664 (0.098)
L-4D (cm)	71.62±3.67	2.76±3.90	-1.513 (0.134)	80.36±5.41	68.1±3.82	*13.081 (<0.001)*	78.86±5.76	7487±4.23	*4.832 (<0.001)*
R-2D:4D	0.98±0.06	1.01±0.02	*-3.559 (0.001)*	0.97±0.03	1.01±0.03	*-5.806 (<0.001)*	0.98±0.03	1.02±0.02	*-9.303 (<0.001)*
L-2D:4D	0.99±0.03	1.00±0.03	*-2.788 (0.006)*	0.97±0.04	1.01±0.02	*-6.151 (<0.001)*	0.98±0.03	1.00±0.12	-1.587 (0.115)

Table 2: The descriptive characteristics and test of mean differences in 2D, 4D length and ratios of males that do not participate in sports (control) and those that generally participate in sport

Variables	Non-sports			Non-hand sports			Hand sports		
	Mean±S.D		T-test	Mean±S.D		T-test	Mean±S.D		T-test
	M (N=50)	F (N=50)	t-value (Sig)	M (N=50)	F (N=50)	t-value (Sig)	M (N=75)	F (N=75)	t-value (Sig)
Age (yrs)	23.70±5.60	22.92±4.85	N/A	22.00±2.93	23.4±3.53	N/A	23.88±5.58	21.61±3.67	N/A
R-2D (cm)	70.19±5.92	73.19±4.35	*-2.884 (0.005)*	77.65±5.61	69.25±3.46	*9.022 (<0.001)*	77.23±5.79	76.7±5.39	0.577 (0.565)
R-4D (cm)	71.93±3.87	72.48±4.12	-0.686 (0.495)	79.95±5.62	68.81±4.20	*11.221 (<0.001)*	78.99±5.74	75.31±4.53	*4.354 (<0.001)*
L-2D (cm)	70.72±3.97	72.85±4.12	*-2.638 (0.01)*	77.82±5.87	68.57±3.57	*9.511 (<0.001)*	77.28±5.50	75.11±9.91	1.664 (0.098)
L-4D (cm)	71.62±3.67	72.76±3.90	-1.513 (0.134)	80.36±5.41	68.1±3.82	*13.081 (<0.001)*	78.86±5.76	74.87±4.23	*4.832 (<0.001)*
R-2D:4D	0.98±0.06	1.01±0.02	*-3.559 (0.001)*	0.97±0.03	1.01±0.03	*-5.806 (<0.001)*	0.98±0.03	1.02±0.02	*-9.303 (<0.001)*
L-2D:4D	0.99±0.03	1.00±0.03	*-2.788 (0.006)*	0.97±0.04	1.01±0.02	*-6.151 (<0.001)*	0.98±0.03	1.00±0.12	-1.587 (0.115)

Table 3: The descriptive characteristics and test of mean differences in 2D, 4D length and ratios of females that do not participate in sports (control) and those that generally participate in sport

Variables	Descriptive Statistics			T-test of mean difference		
	Groups	N	Mean±S.D	Mean difference	t-value	Sig.
R-2D	Non-sports	50	73.19±4.35	-0.533	-0.655	0.5130
	Sports	125	73.72±5.69			
R-4D	Non-sports	50	72.48±4.12	-0.229	-0.303	0.7630
	Sports	125	72.71±5.43			
L-2D	Non-sports	50	72.85±4.12	0.361	0.374	0.7090
	Sports	125	72.49±8.60			
L-4D	Non-sports	50	72.76±3.90	0.599	0.827	0.4100
	Sports	125	72.16±5.25			
R-2D:4D	Non-sports	50	1.01±0.02	-0.005	-1.324	0.1880
	Sports	125	1.01±0.03			
L-2D:4D	Non-sports	50	1.00±0.03	-0.003	-0.220	0.8260
	Sports	125	1.00±0.09			

Table 4a: Dunnett T3 test of mean differences in 2D, 4D length and ratios of males among the three groups

Variable	ANOVA Between group analysis			
	Sum of Squares	Mean Square	F - value	Sig.
R - 2D	1860.77	930.385	27.868	<0.001
R - 4D	2004.451	1002.226	36.482	<0.001
L - 2D	1648.186	824.093	30.136	<0.001
L - 4D	2263.573	1131.786	42.787	<0.001
R - 2D:4D	0.001	0.001	0.27	0.764
L - 2D:4D	0.01	0.005	4.937	0.008

Table 4b: Post Hoc test of multiple comparison

Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
R - 2D	Non-sports	Non-hand sports	-7.46	1.15	*<0.001*
		Hand sports	-7.04	1.07	*<0.001*
	Non-hand sports	Hand sports	0.43	1.04	0.967
R - 4D	Non-sports	Non-hand sports	-8.02	0.97	*<0.001*
		Hand sports	-7.05	0.86	*<0.001*
	Non-hand sports	Hand sports	0.96	1.04	0.729
L - 2D	Non-sports	Non-hand sports	-7.10	1.00	*<0.001*
		Hand sports	-6.56	0.85	*<0.001*
	Non-hand sports	Hand sports	0.53	1.05	0.941
L - 4D	Non-sports	Non-hand sports	-8.74	0.92	*<0.001*
		Hand sports	-7.24	0.84	*<0.001*
	Non-hand sports	Hand sports	1.50	1.01	0.368
R-2D:4D	Non-sports	Non-hand sports	0.00	0.01	0.983
		Hand sports	0.00	0.01	0.992
	Non-hand sports	Hand sports	-0.01	0.01	0.692
L-2D:4D	Non-sports	Non-hand sports	0.02	0.01	*0.012*
		Hand sports	0.01	0.00	0.407
	Non-hand sports	Hand sports	-0.01	0.01	0.161

Table 5a: Dunnett T3 test of mean differences in 2D, 4D length and ratios of females among the three groups

Variable	ANOVA Between group analysis			
	Sum of Squares	Mean Square	F-value	Sig.
R-2D	1675.103	837.55	39.361	<0.001
R-4D	1270.003	635.00	33.995	<0.001
L-2D	1285.529	642.77	12.678	<0.001
L-4D	1390.197	695.10	42.92	<0.001
R-2D:4D	0.004	0.002	3.295	0.039
L-2D:4D	0.001	0.00	0.074	0.929

Table 5b: Post Hoc test of multiple comparison

Variable	(I) Group	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
R-2D	Non-sports	Non-hand sports	3.94	0.79	<0.001
		Hand sports	-3.51	0.87	<0.001
	Non-hand sports	Hand sports	-7.45	0.79	<0.001
R-4D	Non-sports	Non-hand sports	3.67	0.83	<0.001
		Hand sports	-2.83	0.78	0.001
	Non-hand sports	Hand sports	-6.50	0.79	<0.001
L-2D	Non-sports	Non-hand sports	4.28	0.77	<0.001
		Hand sports	-2.25	1.28	0.226
	Non-hand sports	Hand sports	-6.53	1.25	<0.001
L-4D	Non-sports	Non-hand sports	4.66	0.77	<0.001
		Hand sports	-2.11	0.74	0.015
	Non-hand sports	Hand sports	-6.78	0.73	<0.001
R-2D:4D	Non-sports	Non-hand sports	0.00	0.00	0.992
		Hand sports	-0.01	0.00	0.078
	Non-hand sports	Hand sports	-0.01	0.00	0.118
L-2D:4D	Non-sports	Non-hand sports	-0.01	0.00	0.572
		Hand sports	0.00	0.01	1.000
	Non-hand sports	Hand sports	0.00	0.01383	0.983

DISCUSSION

From this study, it can be seen that the 2D:4D is a good criterion in distinguishing male sport participants from male non-sport participants because the digit ratio of the sports group was significantly lower than the non-sport group. This corresponds with the findings of Koziel[3] who noted a significantly lower male 2D:4D in individual sports groups than team-based sports or non-sports group generally. It is also consistent with the findings of [13] who noted a significantly lower 2D:4D amongst male Indian swimmers.

For the female subjects, there was a significant difference between the digit lengths of sports and non-sport participants, with the non-sport group showing relatively higher digit lengths. However, there was no significant difference in the 2D:4D amongst them although they generally showed high ratios compared to the males. This suggests that digit ratio is not a good marker for determining sport abilities in females but the variations in digit length can distinguish them. This corresponds with the findings ofOladipo[2]in the study of 2D:4D and its relevance in the choice of female footballer athletes and female non-footballer athletes in Nigeria. No significant difference in the digit ratio of female sport and non-sport participants was observed, hence it was concluded that digit ratio is not a good criterion for distinguishing them. On the contrary, the recent study by[10] discovered in the United States that college-aged women who played sports that required frequent overhand throwing (e.g. softball, water polo, volleyball, etc.) had statistically smaller digit ratios on each hand than those that played other sports and non-sport participants generally. It was then concluded that digit ratio alone may not be an accurate predictor of the effects of prenatal exposure of testosterone on the traits commonly associated with athletic behavior and performance in women.

In addition, the differences in the female digit lengths of the sports and non-sport groups in this this study suggest that the digit length of females may be adopted as an adequate marker and a predictor of potential sporting ability. This is in tandem with the findings of Oladipo[2] who discovered that the digit lengths (2D and 4D) are significant determinants of sports in female footballer athletes, with sports groups showing significantly shorter digits. It was therefore concluded that there is an association between digit lengths and sporting abilities.

From this study, it can be seen that the 2D:4D variable and its components are sexually dimorphic variables. Male and female non-sport, hand-sport and general sport participants exhibit different second and fourth digit lengths and ratios comparatively, with the males having generally lower digit ratios than the females. This similar with the findings of [14] in their study of 2D:4D and its implication in medicine. They explored relevant molecular basics and the methods of measurement of digit ratios and concluded that digit ratio is sexually dimorphic and can be used as window for in utero exposure to androgens, especially testosterone.

Putz[15] also agreed that 2D:4D is sexually dimorphic in their study where they established that the expression of sex hormones that determine 2D:4D, correlate with certain variables like sexual orientation, spatial ability, status, physical prowess, components of reproductive success, voice pitch, socio-sexuality, mating success, and fluctuating asymmetry.

The sexual dimorphism in this study is also similar with the findings of Oladipo[16] in the study of 2D:4D ratio amongst Nigerian Igbo and Yoruba tribes. It was established that 2D:4D is sexually dimorphic in the two tribes however, it may not necessarily be affected by tribe and ethnicity.

CONCLUSION

The findings of this study suggest that second and fourth digit lengths and ratios can be adapted as sufficient markers for ascertaining an individual's sporting tendencies for various sport types. Furthermore, evidence has been provided that lower 2D:4D is associated with participants of hand related sports than other sports group. The sexual dimorphism should be put into consideration as well as the age and the hand being measured.

REFERENCES

1. Voracek, M. &Pietschnig, J. Digit Ratios, Finger Length, And Basic Musical Abilities *PsychologicaBelgica.*2009; 49(1): 1-18
2. Oladipo, G.S., Anugweje, K.C., Ekezie, J., Amasiatu, V.C., Ipigansi, U.N. and Enefe, G.. Second digit length, fourth digit length and second to fourth digit ratio (2D:4D): Relevance in the choice of female footballer athletes and female non-footballer athletes in Nigeria. *AnthropologyOpen Journal.* 2017; 2(1): 23-28
3. Koziel, S.,Kociuba, M., Ignasiak, Z. and Chakraborty, R. Is sports choice and participation related to 2D:4D? A study among adult male students in Wroclaw, Poland. *College Anthropology.* 2016; 40 (2): 105–106
4. Manning, J., Bundred, P., Newton, D. and Flanagan, B. The second to fourth digit ratio and variation in the androgen receptor gene. *Evolution and Human Behavior.*2003; 24(6): 399-405
5. Yesalis, C.E., Courson, S.P. and Wright, J.E. History of anabolic steroid use in sport and exercise. *Champaign, Illinois: Human Kinetics.* 2000; 2(20): 51-71.
6. Manning, J.T. The ratio of 2nd to 4th digit length and performance in skiing. *Journal for Sports, Medical and Physical Fitness.* 2002; 4(2): 446-450
7. Manning, J.T. and Taylor, R.P. Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. *Evolution and Human*

Behavior. 2001; 22(5): 61-69.

8. Martin, S.M., Manning, J.T., and Dowrick, C.F. Fluctuating asymmetry, relative digit length and depression in men. *Evolution and Human Behavior.* 1999;*20(12)*: 203-214
9. McFadden, D., Loehlin, J.C., Breedlove, S.M., Lippa, R.A., Manning, J.T., and Rahman, Q. A reanalysis of five studies on sexual orientation and the relative length of the 2nd and 4th fingers (the 2D:4D ratio). *Archives of SexualBehavior.* 2005;*34(7)*: 341-356
10. Lombardo, M.P., Otieno, S. and Heiss, A. College aged women in the United Srtates that play Overhand throwing Sports have Masculine Digit Ratios. *Plos One.*2018; 13(9): 2-17
11. Hull, M., Schranz, N.k., Manning, J.T. and Tomkinson, G. *American Journal of Human Biology.* 2015;27(10): 157-160
12. *Frick, N.A., Hull, M., Manning, J. and Tomkinson, G.* Relationships between Digit Ratio (2D:4D) and Basketball performance in Australian Men. *American Journal of Human Biolog. 2016;*29(3):12
13. Sudhakar, H.H., Veena, U.B. and Tejaswi, R.N. Digit ratio (2D:4D) and performance in Indian swimmers. *Indian Journal of Physiological Pharmacology.* 2013; 57(1): 72-76.
14. Saravanakumar, J. and Prathibha, K. 2D:4D Ratio and its Implication in Medicine. *Journal of Clinical and Diagnostic Research.*2016; 10(12): 1-3
15. Putz, D.A. Gaulin, S.J., Sporter, R.J. and Mcburney, D.H. Sex Hormones and Finger Length. What does 2D:4D Indicate? *Evolution & Human Behavior.* 2004;25: 182-199
16. Oladipo, G.S., Fawehinmi, H.B., Ezon-Ebidor, E., Osunwoke, A. and Ordu, K.S. Second to fourth digit ratio in Nigeria Igbos and Yorubas. *Scientific Research and Essay.* 2009;4(10): 1146- 1148