Flunctuation Symmetry and Heredity Differences Between 2D:4D and 1T: 2T Amongst Families in Ilorin Metropolis of Kwara State, Nigeria

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Abstract

Background: Anthropometric measurements include size such as length, height, weight, surface area, volume, arm length and width, neck circumference, hip, and shoulders width and so on. This study was done to compare 2D:4D and 1T:2T in relation to offspring's inheritance in families. This research compared digit and toe ratio in sexual dimorphism.

Materials and Methods: The study sample comprised of 100 families (100 fathers, 100 mothers and 100 off springs) having no deformity in structure. All measurements were taken using a Vernier caliper with an accuracy of 0.01mm. The information provided from this study is relevant to anthropometry field and heredity.

Results and Discussions: The regression model for estimating the right and left 2nd to 4th digit ratio (2D:4D) and right and 1st to 2nd toe ratio (1T: 2T) of the offspring (O) from the parental (father; F and mother; M) produced a significant (P<0.01) prediction, with a very relevant accuracy 31.59% for left 2D:4D, 9.70% = for right 2D: 4D, 6.24% = very poor for right 1T: 2T, not relevant= 0.00% for left 1T:2T.

Conclusion: The regression summary showed that that both parents were significant in estimating the offspring digit ratio; however, better prediction was observed for the mother when compared to the father.

Keywords: Inheritance; Offspring; Digit Ratio; Toe Ratio; Parents

Introduction

Human toes, fingers, and genitalia all develop about eight to thirteen weeks of gestation [1], and studies shown that their development is influenced by the same directive actions of the homeobox gene complex-most especially HoxA and HoxD groups 11, 12, and 13 [1]. Interference al., 1997). Disruptionsl form of this genetic process could lead to malformations in the digits and urogenital tract such as they are seen in hand-foot-genital syndrome [2]. The ratio of the index finger (2D) and the ring finger (4D) is different in males and females. The digit ratio commonly known as the 2D:4D is the ratio between the length of index finger (2D) to the length of ring finger (4D) [3]. At about eight weeks in utero, the hallux becomes adducted with respect to the other toes, while chondrification of the second through fourth digits continues [4]. It is at this time during embryonic development that androgens are exerting their effects on the urogenital tract, and the same Hox genes appear to be controlling both digit and genital developmental processes [5].

In addition, chondrification (formation of cartilage) of the second metatarsal starts to develop at about seven weeks of embryological development, before that of the hallux ("big" toe) [4]. Previous work for review is the work of Jeffery and Stephen on the brain organization theory, digit ratio and sex difference in performance and cognition being tied to the long reach prenatal hormones. Asymmetry in the toe length as well as the toe length ratio of male and females of studied ethnic groups in Nigeria was observed [6]. In part of being partially heritable [7]. Reported that

2D:4D ratio for both hands were weakly positively correlated (r= 0.18-0.19) within couples. The relationship between the 2D:4D ratio and age throughout life is somewhat uncertain, while some other studies have provided evidence for an increasing digit ratio with age in children [8] and across a considerable range of the lifespan [9]. Intense studies examining 2D:4D ratio in children by various means have indicated that the measure slightly increases in younger males and females with age, with more pronounced effect on the left hand in older children [10,11].

Materials and Method

Study Population

Sample sizes of one hundred family subjects were used. This is selected randomly since the family might contain a father, mother and at least one child. The type of sample size is by purposive sampling and was done in Ilorin metropolis, Kwara state, Nigeria.

Method of Data Collection

Subjects were given informed consent letters with a questionnaire. After signing the letter, the subjects were asked to sit or stand comfortably after adequate explanation of the procedure is done since none of the procedure is invasive, neither harmful nor painful to the volunteers. Great caution was also taken to ensure that there was little or no disturbance to the volunteers.

Digit Anthropometry

The lengths of both the right hand and left second digits and fourth digits were taken using a vernier digital caliper and the length of both right and left first and second toes were also measured and filled into the questionnaires by me. The measurement of the digits starts at the point of the proximal metacarpo-phalangeal joint on the palm, and it is measured linearly to the tip of the finger. Also, the measurements of the toe start at the point of the metatarsal-phalangeal joints on the foot and linearly measured to the tip of the toe. All with the use of a digital vernier caliper (Figure 1,2).

Statistical Analysis

XLSTAT version 2015.4.01 was used to analyze the data, with the confidence level set at 95%. Regression analysis was to test the relationship between parental ratio and offspring ratios. P values less than 0.05 was taken to be significant.

Figure 1: Pictures showing the measurement of 2D (index) of the right hand using a caliper.

Results

The results presented were anthropometric measurements of the digits (2nd and 4th) and foot (1st and 2nd) of families in Ilorin metropolis using 100 families. The values obtained were described as continuous variables described in mean (S.D) for which were presented in tables and graphs. In (Table 1), the median right 2D:4D for the father, mother and offspring were 1.00, 0.99 and 0.97 respectively; with mean± S.D values of 1.000.04, 0.99±0.05 and 0.98±0.05 respectively. The median right IT:2T for the father,

mother and offspring were 1.36, 1.40 and 1.39 respectively; with mean± S.D values of 1.37±0.16, 1.41±0.19 and 1.41±0.22 respectively. The regression model for determining the offspring ratios from the individual parental ratios showed a significant (P<0.05) but poor accuracy for the right 2D: 4D (R^2=6.76%; P=0.001) and IT:2T (R^2=6.76%; P=0.003), while the left 2D: 4D (R^2=20.68%; P<0.001) had a significant fair prediction accuracy, whereas, the predictions of the left IT:2T(R^2=0%; P=0.051)was very poor and not significant (P>0.05) (Table 2).
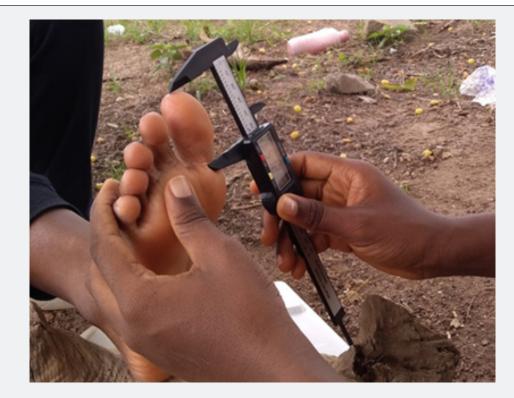

Figure 2: Picture showing the measurement of 1T (first toe) of the right leg using a caliper.

Table 1: Descriptive characteristics of finger- and toe-length ratios measured parameters.

Variable	Mean ± S. D	Minimum	Q1	Median	Q3	Maximum
FR_2D:4D	1.00±0.04	0.9	0.97	1	1.03	1.1
MR_2D:4D	0.99±0.05	0.86	0.96	0.99	1.03	1.08
OR_2D:4D	0.98±0.05	0.87	0.94	0.97	1.02	1.11
FR_IT:2T	1.37±0.16	1.01	1.27	1.36	1.45	1.81
MR_IT:2T	1.41±0.19	1.07	1.3	1.4	1.5	2.42
OR_IT:2T	1.41±0.22	0.95	1.25	1.39	1.55	1.97
FL_2D:4D	0.99±0.04	0.89	0.97	1	1.02	1.07
ML_2D:4D	0.98±0.05	0.89	0.94	0.97	1.01	1.11
OL_2D:4D	0.98±0.05	0.87	0.94	0.98	1.01	1.07
FL_IT:2T	1.37±0.17	0.95	1.28	1.37	1.48	1.81
ML_IT:2T	1.43±0.19	1.02	1.3	1.41	1.52	2.44
OL_IT:2T	1.42±0.21	0.95	1.26	1.42	1.55	2.22

Table 2: Estimating offspring 2D:4D and 1T:2T ratios form paternal 2D:4D and 1T:2T ratios.

	Mother as Predictor						
	Analysis of Variance and Prediction Accuracy					**Model Coefficient Summary**	
	Adj MS	F-Value	P-Value	R-sq. (pred)	Inference	P-value	Regression equation
R_2D:4D	0.0262	11.2	0.001	6.76%	Poor	0.001	0.621 + 0.361 MR_2D:4D
R_IT:2T	0.4305	9.61	0.003	3.67%	Poor	0.003	0.918 + 0.350 MR_IT:2T
L_2D:4D	0.0518	30.17	<0.001	20.68%	Fair	<0.001	0.502 + 0.483 ML_2D:4D
L_IT:2T	0.3145	7.84	0.006	0.68%	V. Poor	0.006	0.997 + 0.294 ML_IT:2T

The regression model for determining the offspring ratios from the individual parental ratios (father) showed a significant ($P<0.05$) but poor accuracy for the right 2D:4D ($R^2=4.13\%$; $P=0.004$) and IT:2T ($R^2=2.51\%$; $P=0.01$), while the left 2D:4D ($R^2=16.59\%$; $P<0.001$) had a significant fair prediction accuracy, whereas, the predictions of the left IT:2T ($R^2=0\%$; $P=0.051$)was very poor and not significant ($P>0.05$) (Table 3). The regression model for estimating the right 2nd to 4th digit ratio (2D: 4D) of the offspring (O) from the parental (father; F and mother; M) produced a significant ($P<0.01$) prediction, with a very unreliable accuracy of 9.70% (*R-sq; pred*) (Table 5 and 4). From the regression summary it was observed that both parents were significant in estimating the offspring digit ratio; however, better prediction was observed for the mother when compared to the father.

Table 3: Estimating offspring 2D:4D and 1T:2T ratios form maternal 2D:4D and 1T:2T ratios.

Offspring	**Father as Predictor**						
	Analysis of Variance and Prediction Accuracy					**Model Coefficient Summary**	
	Adj MS	F-Value	P-Value	R-sq. (pred)	Inference	P-value	Regression equation
R_2D:4D	0.0205	8.54	0.004	4.13%	Poor	0.004	0.619 + 0.359 FR_2D:4D
R_IT:2T	0.3134	6.82	0.01	2.51%	Poor	0.01	0.935 + 0.349 FR_IT:2T
L_2D:4D	0.0431	23.88	<0.001	16.59%	Fair	<0.001	0.428 + 0.553 FL_2D:4D
L_IT:2T	0.0197	0.46	0.501	0.00%	V. Poor	0.501	N/A

Table 4: Regression analysis of variance and model summary (right 2D:4D).

Analysis of Variance					**Model Summary**			
Source	DF	Adj SS	Adj MS	F-Value	P-Value	S	R-sq(adj)	R-sq(pred)
Regression	2	0.03806	0.01903	8.49	0	0.047	13.15%	9.70%
FR_2D:4D	1	0.01186	0.01186	5.29	0.024			
MR_2D:4D	1	0.01759	0.017592	7.85	0.006			
Error	97	0.21735	0.002241					
Total	99	0.25541						

Table 5: Model coefficients (right 2D:4D).

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.397	0.143	2.78	0.007	
FR_2D:4D	0.28	0.122	2.3	0.024	1.06
MR_2D:4D	0.304	0.108	2.8	0.006	1.06

Regression Equation: OR_2D:4D=0.397 + 0.280 FR_2D:4D + 0.304 MR_2D:4D.

The regression model for estimating the right 1st to 2nd toe ratio (1T:2T) of the offspring (O) from the parental (father; F and mother; M) produced a significant ($P<0.01$) prediction, with a very unreliable accuracy of 6.24% (*R-sq; pred*) (Table 6,7). The regression model for estimating the left 2nd to 4th digit ratio (2D:4D) of the offspring (O) from the parental (father; F and mother; M) produced a significant ($P<0.01$) prediction, with a very reliable accuracy of 31.59% (*R-sq; pred*) (Table 8,9). The regression model for estimating the left 1st to 2nd digit ratio (1T:2T) of the offspring (O) from the parental (Father; F and mother; M) produced a significant ($P<0.01$) prediction, with a very irrelevant accuracy of 0.00% (*R-sq; pred*) (Table 10,11).

Table 6: Regression analysis of variance and model summary (right 1T:2T).

	Analysis of Variance					Model Summary		
Source	DF	Adj SS	Adj MS	F-Value	P-Value	S	R-sq(adj)	R-sq(pred)
Regression	2	0.6351	0.31757	7.36	0.001	0.208	11.39%	6.24%
FR_IT:2T	1	0.2046	0.20465	4.74	0.032			
MR_IT:2T	1	0.3217	0.32172	7.46	0.008			
Error	97	4.1851	0.04315					
Total	99	4.8202						

Table 7: Model coefficients (right 1T:2T).

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.586	0.219	2.67	0.009	
FR_IT:2T	0.286	0.131	2.18	0.032	1.03
MR_IT:2T	0.307	0.113	2.73	0.008	1.03

Regression Equation: OR_IT:2T=0.586 + 0.286 FR_IT:2T + 0.307 MR_IT:2T.

Table 8: Regression analysis of variance and model summary (left2D:4D).

	Analysis of Variance					Model Summary		
Source	DF	Adj SS	Adj MS	F-Value	P-Value	S	R-sq(adj)	R-sq(pred)
Regression	2	0.07798	0.038988	26.61	<0.001	0.038	34.09%	31.59%
FL_2D:4D	1	0.02616	0.026161	17.85	<0.001			
ML_2D:4D	1	0.03485	0.034854	23.79	<0.001			
Error	97	0.14214	0.001465					
Total	99	0.22012						

Table 9: Model coefficients(left2D:4D).

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.931	0.211	4.41	0.235	
FL_IT:2T	0.053	0.117	0.45	0.653	1.01
ML_IT:2T	0.29	0.106	2.74	0.007	1.01

Regression Equation: OL_2D:4D=0.140 + 0.442 FL_2D:4D + 0.4061 ML_2D:4D.

Table 10: Regression analysis of variance and model summary (left 1T:2T).

	Analysis of Variance					Model Summary		
Source	DF	Adj SS	Adj MS	F-Value	P-Value	S	R-sq(adj)	R-sq(pred)
Regression	2	0.32277	0.161383	3.99	0.022	0.038	5.69%	0.00%
FL_IT:2T	1	0.00822	0.008225	0.2	0.653			
ML_IT:2T	1	0.30306	0.303057	7.49	0.007			
Error	97	3.92572	0.040471					
Total	99	4.24849						

Table 11: Model coefficients (right 1T:2T).

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.586	0.219	2.67	0.009	
FR_IT:2T	0.286	0.131	2.18	0.032	1.03
MR_IT:2T	0.307	0.113	2.73	0.008	1.03

Regression Equation: OL_IT:2T=0.931 + 0.053 FL_IT:2T + 0.290 ML_IT:2T.

Discussions

The measurement of 2D:4D and 1T:2T are very useful anthropometric dimensions used in sports, clinical practices, sex determination, forensic medicine, and others. Variation in the 2D:4D ratio is quite common favoring females than males because of some genetic, biological, or environmental factors [12]. Observed lower digit ratio in 2D:4D [13]. Found out that there is a small significant difference in toe length ratios like the finger length Ratio which also with my study found small sex differences in toe length ratio and finger length ratio. Besides this study showed difference in index finger and ring finger in sexual dimorphism in line with the observation by [14] who showed that difference existed in the morphology of index and ring fingers across genders. According to [15], it is possible 2D:4D is influenced by a shared genetic factor with mothers and their offspring by some shared biological or environmental factors such as circulating maternal sex hormone levels, which would have been exposed to off springs in utero, this present study showed that offspring's have better correlation with mothers than fathers.

During this study, the 2D:4D and 1T:2T ratio correlated between mother and father and one shared child but had weak significance, and the inheritance of left 2D:4D was higher than right 2D:4D and also the inheritance of right 1T:2T was higher than left 1T:2T [16,17], disagree with this theory by showing there is no evidence for influence of sex linked additive genes to digits but 2 large European studies done by [3,15] indicated positive correlations. Regarding 1T:2T [18], suggested that testosterone affects growth [13]. Attempted to weigh the relationship between toe and finger length but during their study they encountered measurement problems in toe measurements which I also did but found a better way to measure the toes accurately by asking the participant to place his or her foot on a platform which makes the toe face forward and simpler to measure [7]. Also stated that 2D:4D ratio for parents was weakly positively correlated (r= 0.18-0.19) which this study also found. During this research, Morton's toe was observed amongst individuals, but very few and insignificant, so it was not added to the data collected.

Conclusion

This study was able to demonstrate evidence for 2D:4D and 1T:2T ratios being correlated between parents with a shared child, mothers having stronger correlation than the father.

Acknowledgement

References

1. Zakany J, Fromental Ramain C, Warot X, DuBoule D (1997) Regulation of number and size of digits by posterior Hox genes: A dose-dependent mechanism with potential evolutionary implications. Proceedings of the Nat Academy of Sci 94(25): 13695-13700.

2. Innis J (2006) Hand-foot-genital syndrome. Gene reviews, Seattle, WA: University of Washington, Washington, USA.

3. Manning JT (2002) Digit ratio: a pointer to fertility, behavior, and health. New Brunswick NJ: Rutgers univ press 89(5): 403.

4. Bareither D (1995) Prenatal development of the foot and ankle. Journal of the American Podiatric Medi Asso 85(12): 753-764.

5. Garn S, Burdi A, Babler W, Stinson S (1975) Early prenatal attainment of adult metacarpal-phalangeal rankings and proportions. American journal of physical anthropology 43(3): 327-332.

6. Alabi AS, Oladipo GS, Didia BC, Aigbogun EO, Akintunde KA (2017) Hom sapiens are bilaterally symmetrical but not with toe length and toe-length ratio amongst Nigerians. Anatomy J of Africa 6(3): 1024-1033.

7. Manning JT, Churchill AJG, Peters M (2007) The effects of sex, ethnicity, and sexual orientation on self-measured digit ratio (2D:4D). Archives of Sexual Behavior 36: 223-233.

8. Williams JHG, Greenhalgh KD, Manning JT (2003) Second to fourth finger ratio and possible precursors of developmental psychopathology in preschool children. Early Hum Dev 72(1): 57-65.

9. Gillam L, McDonald R, Ebling FJP, Mayhew TM (2008) Human 2D (index) and 4D (ring) finger lengths and ratios: cross-sectional data on linear growth patterns, sexual dimorphism, and lateral asymmetry from 4 to 60 years of age. J of Anatomy 213(3): 325-335.

10. Mcintyre MH (2006) The use of digit ratios as markers for perinatal androgen action. Reproduction boilogy endocrinol 4: 10-19.

11. Hiraishi K, Sasaki S, Shikishima C, Ando J (2012) The second to fourth digit ratio (2D:4D) in a Japanese twin sample: heritability, prenatal hormone transfer, and association with sexual orientation. Arch Sex Behav 41(3): 711-724.

12. Gareth R, Wynford B, William D (2017) Familial digit ratio (2D:4D) association in a general population sample from Wales. Early human development 112(1): 14-19.

13. Mcfadden D, Shubel E (2002) Relative lengths of finger and toes in human males and females. Department of horm and behave 42(4): 492- 500.

14. Manning J, Scutt D, Wilson J, Lewis Jones DI (1998) The ratio of the 2nd and 4th digit length: A predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. Hum Repro 13(11): 3000-3004.

15. Voracek M, Dressler SG, Manning JT (2007) Evidence for assortative mating on digit ratio (2D:4D), a biomarker for prenatal androgen exposure. J of Bios Science 39(4):599-612.

16. Ramesh A, Murty JS (1977) Variation and inheritance of relative length of index finger in man. Ann Hum Bio 4(5): 479-484.

17. Hauth I, De Bruijn YGE, Staal W, Buitelaar JK, Rommelse NN (2014) Testing the extreme male brain theory of autism spectrum disorder in a familial design. Autism Res 7(4): 491-500.

18. Manning J, Dowrick C (1999) Flunctuating asymmetry relative digit length, and depression in men. Evol and Hum Behavior 20(3): 203-214.