Journal of Anatomical Sciences

info@journalofanatomicalsciences.com
submissions@journalofanatomicalsciences.com

J Anat Sci 10 (1)

Validating Sexual Dimorphism in Finger Friction Ridges (Dermatolgyphics) Using Novel Classifications

Aigbogun EO (Jr.)[1*], Ibeachu PC[1], Didia BC[2], Ordu KS
[1]Department of Anatomy, College of Health Sciences, University of Port-Harcourt, Rivers State, Nigeria.
[2]Department of Anatomy, College of Health Sciences, Rivers State University, Rivers State, Nigeria.

Corresponding Author: Aigbogun (Jr.) Eric
E-mail: eric_aigbogun@uniport.edu.ng

ABSTRACT
Aigbogun *et al.* in 2018 introduced a new classification with a wide range of application in anthropological research. This study, therefore, evaluated the distribution of finger friction ridges among University of Port Harcourt students; with the aim validating the assumption of sexual dimorphism in dermatoglyphics. The study was a cross-section analytical research involving randomly selected 100 students (49 male and 51 females) from 10 faculties of the University. The dermatoglyphic characteristics were obtained using the protocol of Oghenemavwe and Osaat (2015); as modified by Aigbogun *et al.* (2018b). The digital dermatoglyphics patterns for the subjects were obtained and the fingers were coded as 1D (thumb) to 5D (little finger); R (right) and L (left). Galton (1988) and Aigbogun *et al*. (2018a) classifications were used to describe the patterns. Sex-associated pattern distribution, combination, and symmetricity were evaluated using Statistical Package for Social Science (Version 23; IBM® Armonk, New York), and Minitab® 2017 (version 18.1) at 95% confidence level ($P<0.05$ was taken to be significant). Using Galton's classification, there was no sex-associated difference in the distribution of the patterns except for R_1D (P=0.039). Using Aigbogun *et al*.'s classification, the distribution of the patterns (L1, W1, A1, AL, AW, and LW) and symmetricity (CS, PS, PAS, with no CAS) was not significantly different (P>0.05). In conclusion, the observed distributional differences in certain patterns between males and females is not an indication of sexual dimorphism, but simply variations. Therefore, to establish dimorphism, group-categorising model must prove at least 75% accuracy for sex discrimination.

Keywords: Dermatoglyphics, Novel classification, Sexual dimorphism, Students, University of Port Harcourt.

INTRODUCTION
When Purkinje[1] (proponent of the first classification) and Herschel [2] studied fingerprint patterns, it was basically for its anatomical features such as specificity, development, and structure;[3,4] however, it was later discovered that the observed ridging of the finger had unique properties, which were combined in different ways and degrees. These features drew attention to the scientific thinking that the patterns can explain differences in temperament, constitution, age, sex, or even family and race.[3]

Galton,[5] Henry,[6] FBI,[7] van Mensvoort[8] and recently Aigbogun *et al*.[9] introduced diverse classification of finger friction ridges to address anthropological problems, identify diversity, establish linkages between the simplest diversity in a population–sex and to complexity in populations–races, evaluate its relationship to diseases and genetic predisposition, as well as estimate heritability.[9]

Establishing sex is a step towards completing the biological profile of an individual; thus, researchers[10,11,12,13,14] have attempted to identify the sexual dimorphic patterns in finger friction ridges (dermatoglyphics) using the different classifications. Despite the vast application of the different classification, their findings have remained inconsistent. This study was therefore carried out to evaluated the finger friction ridge distribution in a simple population, using Galton's[5] classification and the novel classification by Aigbogun *et al*.;[9] with the aim of validating the assumption of sexual dimorphism in dermatoglyphics.

MATERIALS AND METHODS
Ethical considerations
Ethical clearance was obtained from the University Ethics Committee of the Post Graduate School after scrutiny by the Departmental Post Graduate board. Written informed consent was obtained from each family and individual participant after a clear explanation of the research purpose. All statutory and regulatory requirement for the use of humans for experimentation as stated in the "Nuremberg Code" of 1947,[15,16] Helsinki's declaration of 1964,[17] and Belmont report of 1964.[18,19,20]

Research Design
A cross-sectional analytical study was used to validate the application of the classifications in identifying sex associated distribution and differences (Fig. 1). This

research design is characterised by three (3) distinctive features: no time dimension; the need to rely on difference(s) rather than change(s) following intervention; and, selection of groups based on differences that exist (male, female; disorder or normal; healthy or unhealthy) rather than random allocation.[21,22]

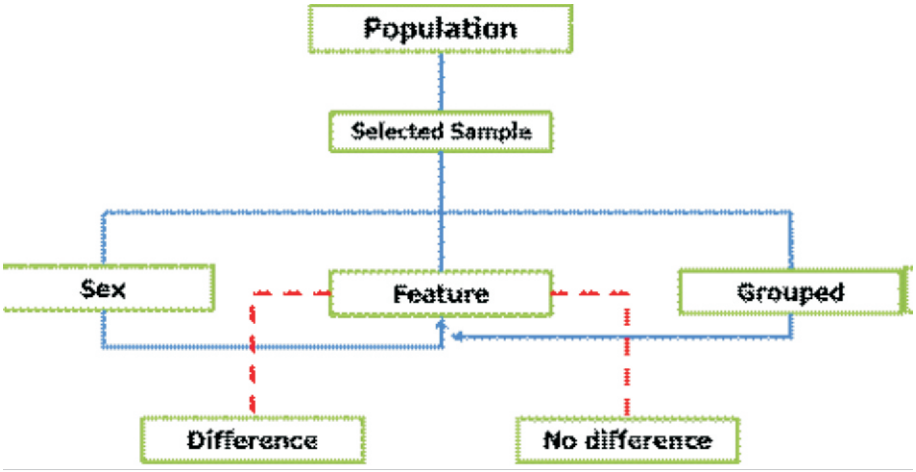

Figure 1: Cross-sectional research design for the study

Sample size and sampling technique

One hundred (100) students made up the sample size and the subjects were obtained through a modified stratified cluster random sampling. Four (4) students (2 males and 2 females) were randomly selected from clusters (10 faculties comprising of 46 departments) in Abuja, Delta, and Choba campuses of University of Port Harcourt. The 46 departments produced a total of 184 students, and the required 100 samples were randomly selected using sequence generation in Excel 2016 sheet.

Data collection using Hp Scanjet 300 flatbed

Digital dermatoglyphic details were obtained using Hp Scanjet 300 flatbed, which has a scanning resolution of 4800x4800 dpi resolutions (Fig. 2). The dermatoglyphic characteristics were obtained using the protocol described by Oghenemavwe and Osaat[23]; with modifications by Aigbogun *et al*.[24] This study only utilised the qualitative dermatoglyphic patterns.

Figure 2: Hp Scanjet 300 flatbed scanner with USB connection to the laptop as power source[24]

Classification pattern for finger friction ridges

The study utilised summarized classifications by Galton[4] and Aigbogun *et al.*[8] (Fig. 3).

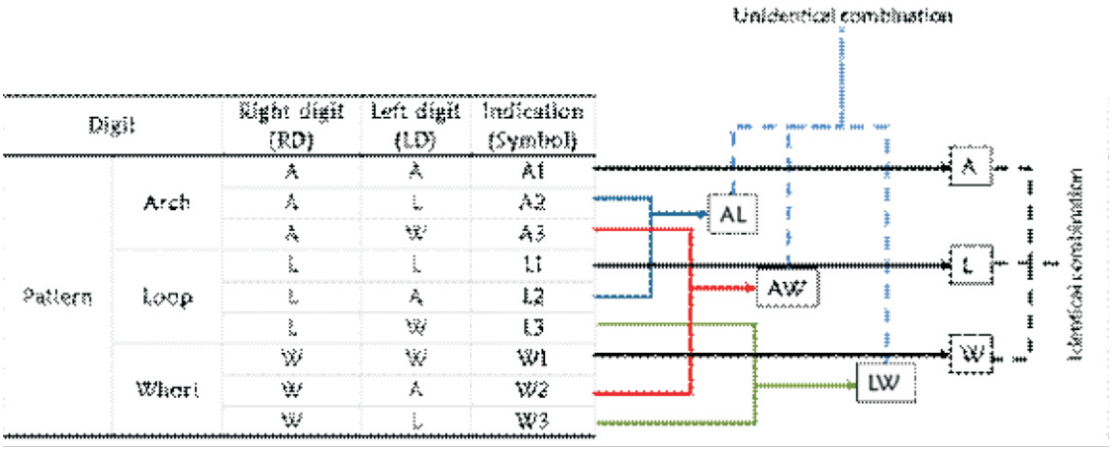

Figure 3: Finger pattern combinations and indications [Summarized version of Aigbogun *et al.*[8] **classification]**

Data analysis

The data were analysed using Statistical Package for Social Science (SPSS Version 23; IBM® Armonk, New York), and Minitab® 2017 (version 18.1) at 95% confidence level ($P<0.05$ was taken to be significant). Descriptive statistics were used to appropriately categorise demographics, frequency, and distribution of the patterns. Fisher's exact (Chi-square) test[25] was used to evaluate sex-associated trends and pattern distribution.

RESULTS

Using the classical classification,[5] the distribution of the fingerprint patterns on the thumb (1D) of both hands of males and females showed that the predominant pattern was whorl (Male [M], 69.4% right [R] and 65.3% left [L]; Female [F], R=59.6% and L=55.8%), followed by loops (R & L=22.4%) for males and arches for female (R=26.9%, L=28.8%). The distributional difference was significant between males and female for the R-1D ($\chi^2_{[df=2]}$=6.500, P=0.039), but not the L-1D ($\chi^2_{[df=2]}$ =4.393, P=0.111). The distribution patterns on the index finger (2D) of both hands in Table 1, males had equal distribution of whorl and loop fingerprint patterns on the R-2D (38.8%) and the L-2D had higher frequency of whorl (44.9%), followed by loops (34.7%), while for females, whorl pattern predominated both digits (R=42.3%; L=44.9%), followed by loop on both digits (R=40.4%; L=34.7%). The distribution on both R- & L-2D were not significantly associated with sex (R; $\chi^2_{[df=2]}$ =0.431, P=0.806), but not the L-1D ($\chi^2_{[df=2]}$ =0.009, P=0.995). The fingerprint distribution on the middle finger (3D) of both hands of males and females were as follows; males and females were predominantly loop on both digits (M, R=61.2% and L=65.3%; F, 57.7% [R & L]), followed by whorl (R & L=26.5%) for males and (R=26.9%, L=28.8%) for females (R=25.0%, L=28.8%). There were no association in the distribution between males and female for the both digits (R-32D; $\chi^2_{[df=2]}$ =0.511, P=0.774 and L-3D; $\chi^2_{[df=2]}$ =0.937, P=0.626). The distribution of the fingerprint pattern on the ring finger (2D) of both hands is presented in Table 1. The predominant patterns were whorl (51.0%) the right and loops (65.3%) on the left for males, followed by loops (46.9%) and whorls (34.7%) on the R & L respectively. For females, the loop was predominant for both R (65.4%) and L (61.5%) followed by whorl (R and L= 30.8%). No significant sex-associated difference in distribution was observed (R; $\chi^2_{[df=2]}$=4.346, P=0.114), but not the L-1D ($\chi^2_{[df=2]}$ =3.945, P=0.139). The distribution of the fingerprint patterns on the little finger (5D) of both hands showed that both males and females were predominantly loop (M, 83.7% [R] and [L]; F, 90.4% [R] and 88.5% [L]), followed by whorl (M, R & L=16.3%; F, R=5.8% and L=9.6%). The distributional difference was significant between males and females for the R-5D ($\chi^2_{[df=2]}$ =4.597, P=0.100), but not the L-1D ($\chi^2_{[df=2]}$=1.892, P=0.388) (Table 1).

Table 1: Pattern distribution in males and females using Galton[5] Classification and test of association

	Right fingers pattern						Left fingers patter n					
	Arch		Loop		Whorl		Arch		Loop		Whorl	
Finger / Sex	M (n=49)	F (n=51)	M (n=49)	F (n=51)	M (n=49)	F (n=51)	M (n=49)	F (n=51)	M (n=49)	F (n=51)	M (n=49)	F (n=51)
Thumb (1D)	4 (8.2)	14 (26.9)	11 (22.4)	7 (13.5)	34 (69.4)	31 (59.6)	6 (12.2)	15 (28.8)	11 (22.4)	8 (15.4)	32 (65.3)	29 (55.8)
	18 (17.8)		18 (17.8)		65 (64.4)		21 (20.8)		19 (18.8)		61 (60.4)	
$\chi 2$ (p-value)			6.50 (0.039)						4.393 (0.111)			
Index (2D)	11 (22.4)	9 (17.3)	19 (38.8)	21 (40.4)	19 (38.8)	22 (42.3)	10 (20.4)	11 (21.2)	17 (34.7)	18 (34.6)	22 (44.9)	23 (44.2)
	20 (19.8)		40 (39.6)		41 (40.6)		21 (20.8)		35 (34.7)		45 (44.6)	
$\chi 2$ (p-value)			0.431 (0.806)						0.995 (0.009)			
Middle (3D)	6 (12.2)	9 (17.3)	30 (61.2)	30 (57.7)	13 (26.5)	13 (25.0)	4 (8.2)	7 (13.5)	32 (65.3)	30 (57.7)	13 (26.5)	15 (28.8)
	15 (14.9)		60 (59.4)		26 (25.7)		11 (10.9)		62 (61.4)		28 (27.7)	
$\chi 2$ (p-value)			0.511 (0.774)						0.937 (0.626)			
Ring (4D)	1 (2.0)	2 (3.8)	23 (46.9)	34 (65.4)	25 (51.0)	16 (30.8)	0 (0)	4 (7.7)	32 (65.3)	32 (61.5)	17 (34.7)	16 (30.8)
	3 (3.0)		57 (56.4)		41 (40.6)		4 (4.0)		64 (63.4)		33 (32.7)	
$\chi 2$ (p-value)			4.346 (0.114)						3.945 (0.139)			
Little (2D)	0 (0)	2 (3.8)	41 (83.7)	47 (90.4)	8 (16.3)	3 (5.8)	0 (0)	1 (1.9)	41 (83.7)	46 (88.5)	8 (16.3)	5 (9.6)
	2 (2.0)		88 (87.1)		11 (10.9)		1 (1.0)		87 (86.1)		13 (12.3)	
$\chi 2$ (p-value)			4.597 (0.10)						1.892 (0.388)			

Note: *X^2=Chi-square, n=distribution, M=Male, F=Female*

Using the new classification,[9] the pattern type distribution observed when corresponding digits were evaluated is presented in Table 2. The outcome of the distributions was as follows: For 1D, W1(53.5%) > A1(14.9%) > L1(9.9%); in males, W1(57.1%) > L1(14.3%) > A1(6.1%) and females, W1(50.0%) > A1(23.1%) > L1(5.8%). For 2D, W1(33.7%) > L1(23.8%) > A1(14.9%); in male, W1(36.7%) > L1(24.5%) > A1(14.3%) and females, W1(30.8%) > L1(23.1) > A1(15.4%). For 3D, L1(51.5%) > W1(22.4%) > A1(6.1%); in males, L1(55.1%) > L1(22.4%) > A1(6.1%) and females, L1(55.1%) > W1(21.4%) > A1(6.1%). For 4D, L1(47.5%) > L1(22.4%) > A1(1.0%); for males, L1(53.8%) > W1(25.0%) > A1(1.9%) and females, L1(53.8%) > W1(25.0%) > A1(1.9%). For 5D, L1(79.6%) > W1(12.2%) > A1(1.0%), in males L1(53.8%) > W1(25.0%) > A1(1.9%) and females, L1(53.8%) > W1(25.0%)>A1(1.9%).

Table 2: Pattern type distribution using the new classification by Aigbogun *et al*.[9] and test of association

Pattern		1D (Thumb)		2D (Index)		3D (Middle)		4D (Ring)		5D (Little)	
		M(%)	F(%)	M(%)	F(%)	M(%)	F(%)	M(%)	F(%)	M(%)	F(%)
ARCH	A1	3(6.1)	12(23.1)	7(14.3)	8(15.4)	3(6.1)	5(9.6)	-	1(1.9)	-	1(2)
	A2	1(2.0)	-	4(8.2)	1(1.9)	-	1(1.9)	-	-	-	-
	A3	-	2 (3.8)	-	-	3(6.1)	3(5.8)	1 (2.0)	1 (1.9)	-	1(2)
		N/A		P=0.194		N/A		N/A		N/A	
LOOP	L1	7(14.3)	3(5.8)	12(24.5)	12(23.1)	27(55.1)	25(48.1)	20(40.8)	28(53.8)	39(89.8)	34(66.7)
	L2	3(6.1)	3(5.8)	4(8.2)	7(13.5)	2(4.1)	3(5.8)	14(28.6)	6(11.5)	2(4.1)	4(7.8)
	L3	1(2.0)	1 (1.9)	3(6.1)	2(3.8)	1(2.0)	2(3.8)	-	3(5.8)	-	-
		P=0.688		P=0.631		P=0.737		N/A		P=0.343	
WHORL	W1	28(57.1)	26(50.0)	18(36.7)	16(30.8)	11(22.4)	11(21.2)	14 (28.6)	13 (25.0)	3 (6.1)	9 (17.6)
	W2	4(8.2)	3 (5.8)	1(2.0)	5(9.6)	2(4.1)	2(3.8)	-	-	-	2 (3.9)
	W3	2(4.1)	2 (3.8)	-	1(1.9)	-	-	-	-	-	-
		P=0.961		N/A		P=0.993		N/A		N/A	

Note: *R=Right, L=Left, M=Male, F=Female, Whorl; RW, LW (W1), RW, LL (W2), RW, LA (W2)*
Loop; RL, LL (L1), RL, LA (L2), RL, LW (L3)
Arch; RA, LA (A1); RA, LL (A2), RA, LW (A3)

The pattern symmetricity and asymmetricity in the distributions in males and females were presented in Fig. 4. Complete symmetry (CS) was generally the same by frequency (4 each; total = 8 [7.9%]), but not by proportion (CS; M=8.2%, F=7.7%), while partial symmetry (PS) was 30.6% in males and 26.9% in females, while partial asymmetry (PAS) was 61.2% and 65.4% in males and females respectively. The distribution was without sexual preference ($\chi^2_{[df=2]}$=0.192, P=0.907). The pattern symmetricity and asymmetricity for the 1D-5D in Table 3 showed slight difference in proportions for males and females; 1D (77.6% and 78.8% symmetricity, and 22.4% and 21.2% asymmetricity for males and females respectively), 2D (75.5% and 69.2% symmetry and 24.5% of males and 30.8% asymmetricity in males and females respectively), 3D had 83.7% and 78.8% symmetricity, with 16.3% and 21.2% asymmetricity in males and females respectively. The symmetry observed for 4D was 69.4% and 80.8%, while asymmetry was 30.6% and 19.2% in males and females respectively. 5D symmetricity was observed in 91.8% and 94.2% of males and female and asymmetry in 8.2% of males and 5.8% of females. No sex-associated distributional difference was observed for all digits (D1-D5); 1D ($\chi^2_{[df=2]}$=0.025, P=0.875), 2D ($\chi^2_{[df=2]}$ =0.496, P=0.481), 3D ($\chi^2_{[df=2]}$=0.385, P=0.535), 4D ($\chi^2_{[df=2]}$=1.755, P=0.185), and 5D ($\chi^2_{[df=2]}$=0.2444, P=0.636).

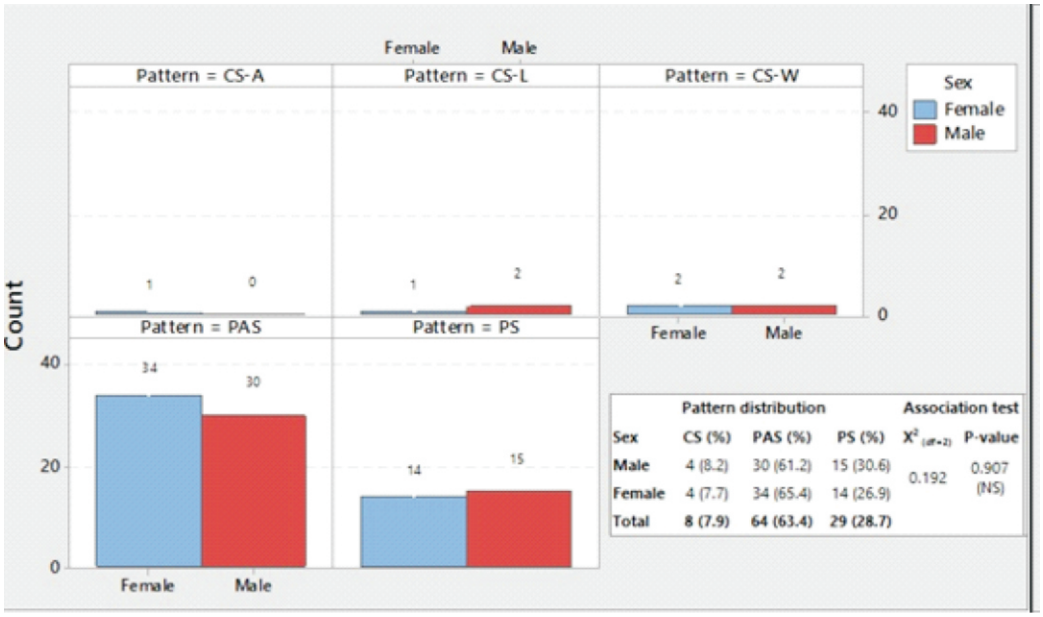

Figure 4: Pattern distribution in male and female population (*CS; complete symmetry and asymmetry, PS; partial symmetry; PAS; partial asymmetry, A; arch, L; loop, W; whorl*)

Table 3: The pattern symmetry and asymmetry on corresponding digits in males and females and test of association

PATTERN	Sex	Distribution		Chi-square analysis			
		Symmetrical	Asymmetrical	Df	X^2	P-value	Inference
Thumb (R1-L1)	Male (%)	38 (77.6)	11 (22.4)	2	0.025	0.875	NS
	Female (%)	41 (78.8)	11 (21.2)				
	Total (%)	79 (78.2)	22 (21.8)				
Index (R2-L2)	Male (%)	37 (75.5)	12 (24.5)	2	0.496	0.481	NS
	Female (%)	36 (69.2)	16 (30.8)				
	Total (%)	73 (72.3)	28 (27.7)				
Middle (R3-L3)	Male (%)	41 (83.7)	8 (16.3)	2	0.385	0.535	NS
	Female (%)	41 (78.8)	11 (21.2)				
	Total (%)	82 (78.8)	19 (18.8)				
Ring (R4-L4)	Male (%)	34 (69.4)	15 (30.6)	2	1.755	0.185	NS
	Female (%)	42 (80.8)	10 (19.2)				
	Total (%)	76 (75.2)	25 (24.8)				
Little (R5-L5)	Male (%)	45 (91.8)	4 (8.2)	2	0.244	0.636	NS
	Female (%)	49 (94.2)	3 (5.8)				
	Total (%)	94 (93.1)	7 (6.9)				

Note: *NS–=Not significant*

In Table 4, the laterality of the fingerprint distribution was recategorized into symmetrical or asymmetrical and the result showed that males exhibited 40.8% symmetricity while females exhibited 34.6% symmetricity. Males exhibited 59.2% asymmetricity while females exhibited 62.4% asymmetricity; the difference in the distribution was without sex preference ($\chi^2_{[df=2]}$=0.413, P=0.52).

Table 4: The pattern symmetry and asymmetry on all digits in males and females and test of association

Sex	**TYPE (1D-5D)**		**Chi-square analysis**			
	S^1	**AS_d**	**Df**	**X^2**	**P-value**	**Inference**
Male (%)	20 (40.8)	29 (59.2)	2	0.413	0.520	NS
Female (%)	18 (34.6)	34 (65.4)				
Total (%)	38 (37.6)	63 (62.4)				

Note: X^2= Chi-square, NS=Not Significant

S^1=*Symmetrical in all 5 fingers*
AS_d=*Asymmetrical in any finger*
A^1=*Asymmetrical in all 5 fingers (0% in both sexes)*

DISCUSSION

The present study evaluated the distribution and combination of finger dermatoglyphic patterns using Galton's[5] and Aigbogun *et al's*[9] Classification a novel classification technique in other to evaluate the extent of sex influence on patterns distribution on the fingers, their symmetricity and asymmetricity on corresponding digits and the entire fingers. In this study, using the classical classification,[5] loop (L) pattern was observed to be the predominant fingerprint, followed by whorl (W) and then arch (A); although not entirely, as observed on the left index finger which had more arch patterns. Similar findings have been reported by Eboh,[12] George and Yassa,[14] and Ujaddughe *et al.*;[26]

as they reported a higher proportion of loops and arches on the left fingers, while whorl was more on the right. The difference in the distribution of the patterns in males and females was only significant for the right thumb (R_1D), which presented with a higher frequency of arch in females and loop in males; however, the distribution in other fingers (R & L) were without sexual preference. The finding of a high frequency of arch in female was in line with the findings by Ekanem *et al*.,[10] Prateek and Keerthi,[11] and Eboh,[12] but contrary to a recent finding by George and Yassa.[18] Using the new classification,[9] certain combination patterns (A2 [4D and 5D], A3 [2D], L3 [5D], W2 [4D], W3 [3D, 4D and 5D]) were absent in both males and females, while the represented patterns did not follow any trend suggestive of sexual influence.

The pattern symmetry and asymmetry using the new classification revealed that males and females had a greater occurrence of whorl on the thumb (1D) and index finger (2D) of both hands while arch was the least exhibited pattern. The study found out that loops had greater occurrence on the middle (3D,) ring (4D), and little (5D) fingers of both hands of males and females, while arch pattern occurred least. Comparatively, on the first digit, whorl had the greater occurrence on both hands (symmetricity), while arche and loop showed a lower frequency of symmetry and the possibility that asymmetry was present in all patterns on the first digit was low. The distribution of patterns in populations have been observed to be diverse,[10,11,12,14,26] and under certain situations, such as sampling method and the population under study, the pattern frequency could change. Additionally, a greater symmetric occurrence of whorls was observed on 2D of both males and females, while arch had the least occurrence. The asymmetric possibilities of loop patterns were obvious in females when compared to males, but generally, the asymmetric occurrence of all the patterns was low. For the 3D, 4D, and 5D, loop exhibited greater occurrence of symmetry on both hands of males and females. The occurrence of symmetry was greatly observed on the 5D; with whorls and arches having lower frequencies.

When the hands (all digits) were observed using the four-pattern classification; complete symmetry (CS), partial symmetry (PS), complete asymmetry (CAS) and partial asymmetry (PAS), the study observed that no individual presented with complete asymmetry, which is defined by complete difference finger friction ridge pattern in the corresponding fingers of all digits. This finding opens a new dimension of investigation in clinical, forensic and physical anthropology; with a baseline question of can a population display complete asymmetry and if such exists what are their uniqueness.

Generally, this study observed that the digits exhibit symmetry and asymmetry, but with a greater frequency of asymmetry. The pattern distribution remained indifferent between males and females and this has been reported by Eboh *et al*.,[12] George and Yassa,[14] Ujaddughe *et al.,*[26] and Osunwoke *et al.*[27] for the for the Urhobo, Ikwerre, and Esan ethnic groups and Egyptians respectively. For the fact that a finger or two showed significant variation in distribution between males and females does not imply the existence of sexual dimorphism. Therefore, to establish the scientific assumption, "Discriminant Analysis" must provide at least 75% group categorisation for anthropological purposes[28,29] and 90% for medicolegal purposes.[28,29,30,31,32] Additionally, most genetic studies of dermatoglyphics[33,34,35,36,37] have not reported any sex-associations in its transmission from parents to offspring and therefore it would be safe to remain within the scientific assumption that they are indeed transmitted, while silently putting aside the sexual dimorphic assumptions.

CONCLUSION

The fact that certain patterns types and combinations exhibit sex-associated distributional differences is not suggestive or indicative of sexual dimorphism, but simple pattern variations; therefore, in order to establish sexual dimorphism, classification models must prove that the predicting variables can achieve at least 75% accuracy for sex discrimination.

RECOMMENDATION

There is need for extensive investigation into the implication of the new classification technique; so as to establish the significance of these patterns in anthropological studies.

REFERENCES

1. Purkinje JE. Commentatio de examine physiologico organi visus et systematis Cutanei. Breslau: Vratislavie. Typis Universitatis. 1823.
2. Herschel WJ. Skin furrows of the hand. Nature. 1880; 76.
3. Cummins H, Kennedy RW. Purkinje's Observations (1823) on Finger Prints and Other Skin Features. J. Crim. L. & Criminology. 1940; 31(3): 343–56.
4. Grzybowski A, Pietrzak K. Jan Evangelista Purkynje (1787-1869): first to describe fingerprints. Clin Dermatol. 2015; 33(1): 117–21.
5. Galton F. Finger Prints. London, and New York: McMillan & Co. 1892.
6. Henry ER. Classification and Uses of Fingerprints (1st ed.). Routledge & Sons: London. 1900.
7. Federal Bureau of Investigation (FBI). The Science of Fingerprints: Classification and Uses. Department of Justice - Government Printing Office. 1988; 211 pages.
8. van Mensvoort M. FINGERPRINTS. The Classification of Fingerprint Types & Dermatoglyphics. 2017 [Cited August 20, 2018]. Available from: http://www.handresearch.com/diagnostics/fingerprints-classification.htm.
9. Aigbogun (Jr.) EO, Ibeachu PC, Didia BC, Ordu KS. A novel classification for finger friction ridges (dermatoglyphic patterns). European J Biomed Pharm Sci. 2018a; 5(11): 115–20.

10. Ekanem EP, Ehwa MA, Udoaffah GU, Ekanem TB, Akpantah AO. Digital dermatoglyphic patterns of Annang ethnic group In Akwa Ibom State of Nigeria. Internet J Biol Anthropol. 2009; 3(1).
11. Prateek R, Keerthi, RP. A study of fingerprints in relation to gender and blood group. JIAFM. 2010; 32 (1): 11–4.
12. Eboh DEO. Digital Dermatoglyphic Patterns of Anioma and Urhobo Students in Two tertiary Institutions of Delta State, Southern Nigeria. JMBR. 2012; 11(2): 90–6.
13. Amit AM, Anjulika AM. Study of fingerprint patterns among medical students in Vidarbha region India. IJAR. 2015; 3(2): 1043–5.
14. George SM, Yassa HA. Sexual dimorphism in fingerprint pattern: A tool for sex identification. ZJFM. 2018; 16(1): 1–9.
15. Perlman D. Ethics in clinical research a history of human subject protections and practical implementation of ethical standards. Society of Clinical Research Associates. 2004; 37–42.
16. Rahemtula A, Reginbogin HR, Christoph JM, Safferling CJM, Hippel WR. The Nuremberg Trials: International Criminal Law Since 1945 = Die Nürnberger Prozesse: Völkerstrafrecht seit 1945. AARL. 2007; 38(2): 162–3.
17. Snežana B. The declaration of Helsinki: The cornerstone of research ethics. Articles in Archive of Oncology. 2001; 9(3): 179–84.
18. National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, Department of Health, Education and Welfare (DHEW). The Belmont Report (PDF). Washington, DC: United States Government Printing Office. 1978.
19. Vanderpool HY. The Ethics of Research Involving Human Subjects: Facing the 21st Century. Frederick, MD: University Publishing Group. 1996.
20. Vollmer SH, George H. Statistical power, the Belmont Report, and the ethics of clinical trials. Science and Engineering Ethics. 2010; 16: 675–91.
21. Bethlehem J. Cross-sectional Research (Chapter 7). In. In Adèr, H.J., and Mellenbergh, G.J. Eds. Research Methodology in the Social, Behavioural and Life Sciences. London, England: Sage; 1999. p. 110–143
22. Hall J. Cross-Sectional Survey Design. In Encyclopedia of Survey Research Methods. Lavrakas, P.J. eds. Thousand Oaks, CA: Sage. 2008; p. 173–4.
23. Oghenemavwe EL, & Osaat RS. (2015). An improvise easy digital method for palmar dermatoglyphics. Bioscience & Bioengineering. 1(3): 85–59.
24. Aigbogun (Jr.) EO, Ibeachu PC, Didia BC, Ordu KS, Alabi SA, Benwoke WI. An alternative to the use of HP G3110 Scanjet for digital dermatoglyphics. IJST. 2018b; 6(10): 51–6.
25. Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991.
26. Ujaddughe MO, Abue AD, Izunya MA, Ezeuko VC, Eze IG, Baxter-Grillo D. Assessment of Dermatoglyphic Patterns and Sex Distribution in Esan Ethnic Group of Edo State, Nigeria. IJBAIR. 2015; 4(1): 9–14.
27. Osunwoke EA, Ordu KS, Hart J, Tamunokuro FB. A Study on the Dermatoglyphic patterns of Okrika and Ikwerre Ethnic groups of Nigeria. *Scientia Africana*. 2008; 7(2): 143–7.
28. Ibeachu PC, Aigbogun E, Didia BC, Fawehinmi HB. Determination of Sexual Dimorphism by Odontometric Study using Discriminante Function Analysis of Adult Ikwerre Dental cast, *SJAMS.* 2015; 3(4B): 1732–8.
29. Alabi SA, Didia BC, Oladipo GS, Aigbogun EO. Evaluation of sexual dimorphism by discriminant function analysis of toe length (1T-5T) of adult Igbo populace in Nigeria. *Niger Med J.* 2016; *57*(4): 226–32.
30. Iscan MY. Forensic anthropology of sex and body size. Forensic Sci. Int. 2005; 147: 107–12.
31. Iscan MY, Miller-Shaivitz P. Determination of sex from the tibia. Am J Phys Anthropol. 1984; 64: 53–7.
32. Iscan MY, Shihai D. Sexual dimorphism in the Chinese femur. Forensic Sci. Int. 1995; 4: 79–87.
33. David TJ, Darke C, Bender K, Ray BD. Linkage study on the "ridges-off-the-end" and Nelson syndromes. Hum Hered. 1973; 23: 280–7.
34. Matsuda E. Genetic studies on total finger ridge-count. Jpn J Hum Genet. 1973; 17: 293–318.
35. Froehlich JW. The usefulness of dermatoglyphics as a biological marker of human populations in Melanesia. Ph.D. dissertation, Harvard University, Cambridge, Massachusetts; 1973.
36. Chakraborty R. The role of heredity and environment on dermatoglyphic traits. In Dermatoglyphics: Science in Transition; March of Dimes: Washington, DC; 1991. p. 151–91.
37. Yang X, Xiaojun J, Yixuan Z, Hui L. Genetic rules for the dermatoglyphics of human fingertips and their role in spouse selection: a preliminary study. Springer Plus. 2016; 5: 1396.