

RESEACH ARTICLE

ETHNIC VARIATION AND SEXUAL DIMORPHISM IN FINGERPRINT WHITE LINE OF FULANI AND HIGGI TRIBES OF MICHIKA, NIGERIA

*I. A. Atiku¹, M. Tanko², L. H. Adamu¹, S. A. Musa², S. S. Adebisi², B. Danborn².

¹Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medicine and Allied Medical Sciences, Federal University Dutse, Jigawa State, Nigeria

²Department of Human Anatomy, Faculty of Basic Medical Sciences, Ahmadu Bello University Zaria, Kaduna State, Nigeria

Abstract

Background: Human identification and authentication in biometrics and forensic sciences have been key processes particularly with the advent of smart technology. Fingerprint is crucial in this regard. **Aim:** This study aimed to determine ethnic variation and sexual dimorphism in fingerprint white line of Fulani and Higgi tribes of Michika, Nigeria. **Methodology:** 511 participants of 5 to 19 years were recruited. These constituted both Fulani and Higgi male and female. Fingerprints of all ten digits were captured using live scanner device and white line counts were determined. Data were expressed in mean \pm SD, frequency and percentages. Sexual dimorphism and ethnic differences were determined using independent sample t test. SPSS version 26.0 statistical software was used for statistical analysis and $p < 0.05$ was set as the level of significance. **Results:** White lines showed significant ethnic differences in both sexes and on both hands, the largest $t = 3.73$ and $p < 0.001$ was recorded in female left thumbs. Fulani displayed more white lines with a larger mean of 2.18 ± 1.97 than the Higgi with a mean of 1.34 ± 1.57 . Significant sex differences were observed in all the fingers with a $p < 0.001$ all through, the largest $t = 4.47$, was recorded in index of Fulani right hand, where female displayed more white lines with a larger mean of 0.96 ± 1.84 than male with a mean of 0.19 ± 0.55 . **Conclusion:** The study revealed ethnic differences and sexual dimorphism in fingerprint white lines of Fulani and Higgi tribes of Michika, Adamawa state, Nigeria. The data generated in this study would be used as a reference data of the population in a forensic investigation.

Keywords: Fingerprint, white-line, ethnic differences, sexual dimorphism, Michika, Higgi, Fulani.

INTRODUCTION

Human identification and authentication in biometrics and forensic sciences have been key processes, particularly with the advent of smart technology (Saini and Kapoor, 2016). Fingerprinting is crucial in this regard. Fingerprint is an impression left by the friction ridges of the finger tips (Reka, 2012). The formation of fingerprint ridges is under the influence of genetic and environmental factors. Hence, variation in fingerprint ridge configuration is unique among individuals including identical twins (Sharma et al., 2022). Fingerprint features suggested to have the potential in personal identification include ridge pattern, ridge density, ridge thickness, minutiae, ridge pores, ridge

contour, ridge shape, and white line, among others (Adamu et al., 2019; Atiku et al., 2023 & 2024). In an effort to improve forensic sciences, fingerprints have been studied in different parts of the world; African populations such as Nigerians (Atiku et al., 2018; Adamu et al., 2022), Sudanese (Ahmed & Osman, 2016), Egyptians (Eshak et al., 2013), Asian populations such as Chinese and Malaysians (Nayak et al., 2010; Vinod et al., 2010), Indian populations (Nithin et al., 2011). Indo-Mauritian populations (Agnihotri et al., 2012), European populations, Spanish Caucasians (Gutierrez-Redomero et al., 2008) Latin American populations, and Argentinean populations

(Noemí et al., 2015; Rivalderia et al., 2016). Even though researches have been conducted on fingerprints using ridge density, ridge thickness and other minutiae in sex determination and age prediction, only few studies have been reported so far on the potential role of Fingerprint White Line (FWL) in sex determination (Badawi et al., 2006; Tadurana et al., 2016; Adamu et al., 2019). More so, no record of research had conducted on Fulani and Higgi ethnic groups as at the time this research was conducted. This study aimed to determine ethnic variation and sexual dimorphism in fingerprint white line of Fulani and Higgi tribes of Michika, Nigeria.

name from Madibbo Adama, a Fulani cleric who led the 19th century Jihad in Upper Benue Region under Othman Dan Fodio (Diouf, 2003). Adamawa state is known for its diverse cultural heritage; in addition to the dominant Fulani, the state is inhabited by other minority ethnic groups, such as Margi, Bachama, Mumuye, Higgi, Chamba, Hausa, Kilba, Gude, Wurkum, Jukun, and Bata among others (Heine and Derek, 2008). The Higgi ethnic group lives mainly in the towns of Michika with the GPS coordinates of (10° 37'0.0012" N and 13° 22'59.9988" E) and Bazza in Adamawa state. However, another section of the Higgi ethnic group is located in the Republic of Cameroon. They are called Kapsiki (Van Beek, 2012).

MATERIALS AND METHODS

This study was conducted in Michika Local Government Area, Adamawa State, Nigeria. Adamawa State derived its

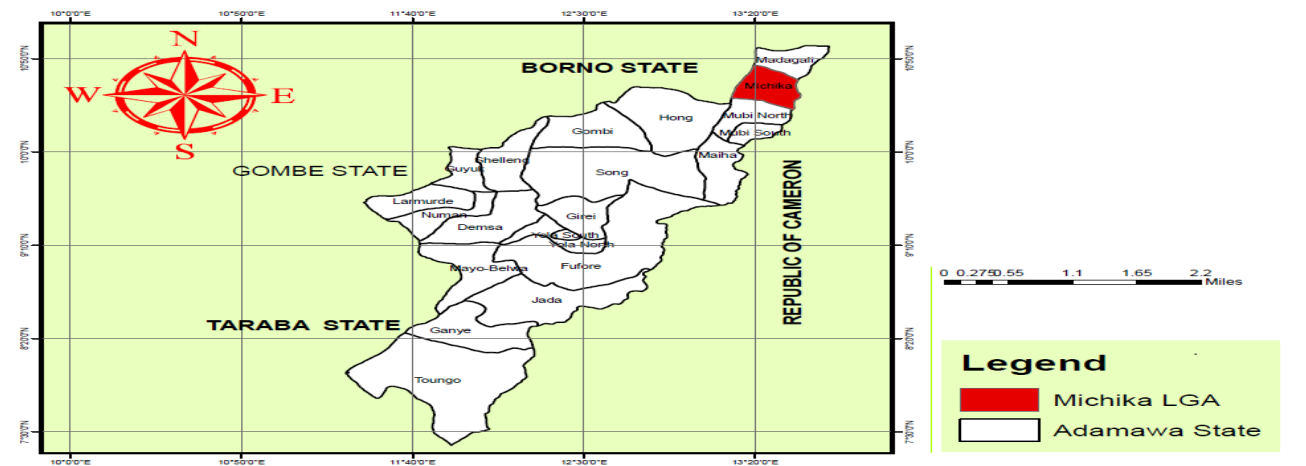
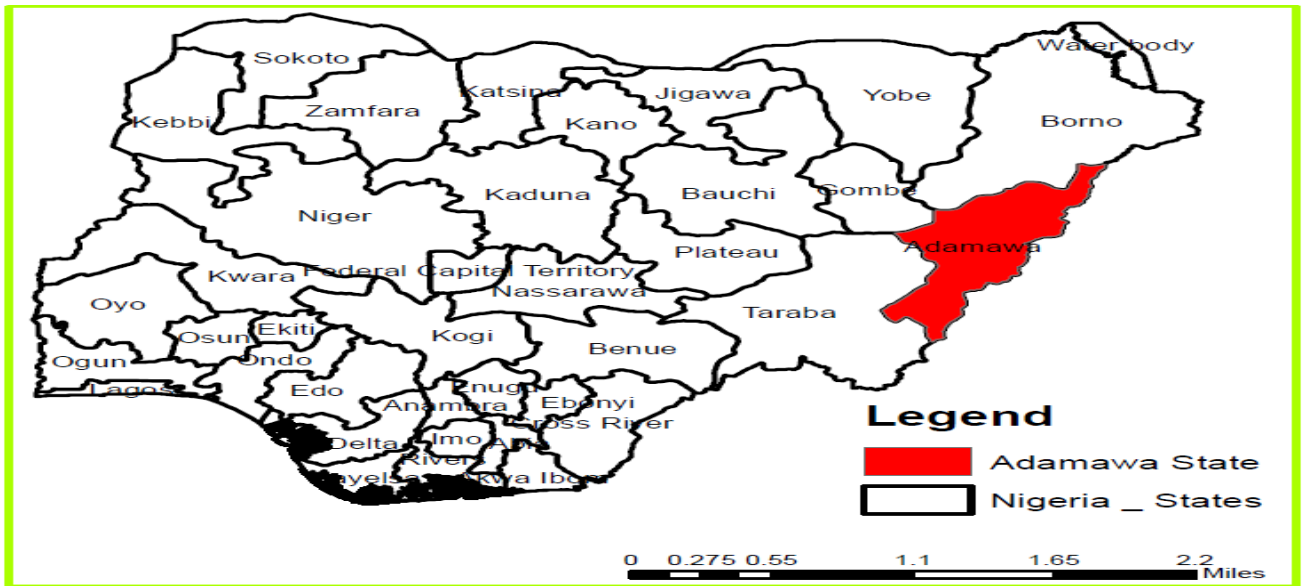


Figure 1: (a) Map of Nigeria with study location

(b) Map of Adamawa with study area

Five hundred and eleven participants of 5 to 19 years were recruited in this study. These constituted both Fulani and Higgi male and female indigenous of Michika. Fingerprints of all the 10 digits were captured using live scanner device and white line counts were determined by counting the

number of creases that crossed two or more ridges irrespective of the orientation and direction of the creases.

FWL count for each digit was considered as the number of the observed white lines per unit plain fingerprints (Figure 2).

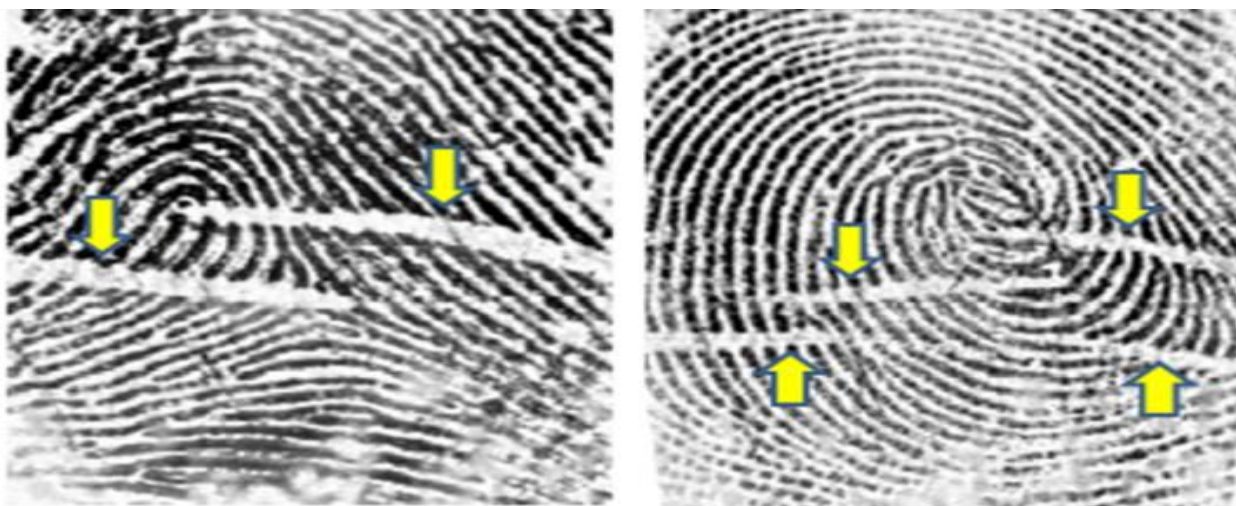


Figure 2: White line count

Data were expressed in mean \pm SD, frequency and percentages. Sexual dimorphism and ethnic differences were determined using independent sample t test. SPSS version 26.0 statistical software was used for statistical analysis and $p < 0.05$ was set as the level of significance.

RESULTS

In thumb, white lines showed significant differences between Fulani and Higgi in both male and female and on both hands, the largest $t = 3.73$, and $p < 0.001$ was recorded in female left hand. Fulani displayed more white lines with a larger mean of 2.18 ± 1.97 than the Higgi with a mean of 1.34 ± 1.57 . Fulani displayed more white lines in both sexes and on both hands (Table 1). In index, Fulani displayed more white lines with a larger mean of 0.96 ± 1.84 than the Higgi with a mean of 0.44 ± 1.04 ($t = 2.74$, $p = 0.01$) (Table 1). In middle fingers, the significant difference was observed in all female, in the case of male only WL of the right middle finger significantly differed

between Fulani and Higgi. Fulani displayed more white lines in both sexes and on both sides (Table 1). In ring fingers, Fulani displayed more white lines with a mean of 1.61 ± 2.74 than Higgi with a mean of 0.87 ± 1.67 , ($t = 2.62$, $p = 0.01$) (Table 1). In little finger, white lines were found to showed significant difference in both sexes except male right, the largest $t = 3.98$, and $p < 0.001$ was recorded in female right hand. Fulani displayed more white lines with a mean of 0.94 ± 1.95 than Higgi with a mean of 0.20 ± 0.69 (Table 1). In Fulani ethnic group, white lines showed significant differences in all the fingers with a p -value of less than 0.001 all through, the largest $t = 4.47$, was recorded in index of the right hand, where female displayed more white lines with a larger mean of 0.96 ± 1.84 than the male counterpart with a mean of 0.19 ± 0.55 (Table 2). In Higgi ethnic group, white lines showed significance differences in all the fingers of both hands except right index and right little fingers. The largest $t = 3.37$, was recorded in ring of the right hand, where female displayed more white lines with a larger mean of 0.71 ± 1.48 than the male counterpart with a mean of 0.21 ± 0.75 (Table 2).

TABLE 1: ETHNIC DIFFERENCES IN FINGERPRINT WHITE LINES COUNT

Sex	Finger	Side	Fulani		Higgi		t	p	
			n	Mean± SD	n	Mean± SD			
Male	Thumb	Left	123	1.20 ± 1.48	127	0.81 ± 1.15	2.28	0.023	
		Right	123	0.87 ± 1.22	131	0.55 ± 0.97	2.31	0.022	
	Index	Left	123	0.33 ± 0.70	128	0.32 ± 0.81	0.05	0.961	
		Right	124	0.19 ± 0.55	128	0.30 ± 0.72	-1.38	0.170	
	Middle	Left	123	0.34 ± 0.86	129	0.26 ± 0.69	0.88	0.380	
		Right	124	0.37 ± 1.02	126	0.11 ± 0.42	2.63	0.011	
	Ring	Left	123	0.51 ± 1.33	128	0.42 ± 1.13	0.58	0.562	
		Right	123	0.29 ± 1.05	129	0.21 ± 0.75	0.73	0.473	
	Little	Left	122	0.20 ± 0.70	125	0.05 ± 0.28	2.18	0.031	
		Right	122	0.21 ± 0.68	130	0.25 ± 0.74	-0.45	0.654	
	Female	Thumb	Left	125	2.18 ± 1.97	125	1.34 ± 1.57	3.73	<0.001
			Right	124	1.66 ± 1.95	125	0.98 ± 1.37	3.21	<0.001
		Index	Left	126	0.98 ± 1.90	125	0.58 ± 1.15	2.02	0.042
			Right	126	0.96 ± 1.84	124	0.44 ± 1.04	2.74	0.012
Middle		Left	127	1.27 ± 2.58	126	0.67 ± 1.66	2.20	0.031	
		Right	126	0.98 ± 1.96	124	0.36 ± 0.86	3.26	<0.001	
Ring		Left	128	1.61 ± 2.74	126	0.87 ± 1.67	2.62	0.013	
		Right	126	1.11 ± 2.10	126	0.71 ± 1.48	1.77	0.082	
Little		Left	123	0.93 ± 2.04	123	0.33 ± 0.95	3.01	<0.001	
		Right	125	0.94 ± 1.95	124	0.20 ± 0.69	3.98	<0.001	

TABLE 2: SEX DIFFERENCES IN FULANI AND HIGGI LEFT AND RIGHT FINGERPRINT WHITE LINES

Ethnicity	Side	Finger	Male		Female		t	p
			n	Mean± SD	n	Mean± SD		
Fulani	Left	Thumb	123	1.20 ± 1.48	125	2.18 ± 1.97	-4.44	<0.001
		Index	123	0.33 ± 0.70	126	0.98 ± 1.90	-3.62	<0.001
		Middle	123	0.34 ± 0.86	127	1.27 ± 2.58	-3.83	<0.001
		Ring	123	0.51 ± 1.33	128	1.61 ± 2.74	-4.07	<0.001
		Little	122	0.20 ± 0.70	123	0.93 ± 2.04	-3.80	<0.001
	Right	Thumb	123	0.87 ± 1.22	124	1.66 ± 1.95	-3.82	<0.001
		Index	124	0.19 ± 0.55	126	0.96 ± 1.84	-4.47	<0.001
		Middle	124	0.37 ± 1.02	126	0.98 ± 1.96	-3.12	<0.001
		Ring	123	0.29 ± 1.05	126	1.11 ± 2.10	-3.90	<0.001
		Little	122	0.21 ± 0.68	125	0.94 ± 1.95	-3.91	<0.001
Higgi	Left	Thumb	127	0.81 ± 1.15	125	1.34 ± 1.57	-3.02	<0.001
		Index	128	0.32 ± 0.81	125	0.58 ± 1.15	-2.04	0.042
		Middle	129	0.26 ± 0.69	126	0.67 ± 1.66	-2.57	0.011
		Ring	128	0.42 ± 1.13	126	0.87 ± 1.67	-2.47	0.013
		Little	125	0.05 ± 0.28	123	0.33 ± 0.95	-3.12	<0.001
	Right	Thumb	131	0.55 ± 0.97	125	0.98 ± 1.37	-2.87	0.010
		Index	128	0.30 ± 0.72	124	0.44 ± 1.04	-1.23	0.223
		Middle	126	0.11 ± 0.42	124	0.36 ± 0.86	-2.93	<0.001
		Ring	129	0.21 ± 0.75	126	0.71 ± 1.48	-3.37	<0.001
		Little	130	0.25 ± 0.74	124	0.20 ± 0.69	0.58	0.562

DISCUSSION

The present study has been conducted to expand the prospect of fingerprints white lines of all the ten fingers. This study revealed ethnic differences and sexual dimorphism in fingerprint white lines. Ethnic differences

in fingerprint white lines were found to exist in both sexes. White lines were found to be more common in Fulani than Higgi in both sexes. However, due to Sexual dimorphism, asymmetry in fingerprint profile and variation within fingers of the same hand, ethnic differences were not observed uniformly (Taura et al., 2019).

These suggest that in determination of ethnic differences using fingerprint white lines, it is very important to consider sex of the individual, side of the hand and the digit. At the moment, data on fingerprint white line count were very limited due to the fact that little attention was given to FWLC in forensic community. Ethnic comparison of FWLC was not available in the literature, however, the mean values of FWLC found in Hausa population (Adamu et al., 2019) were higher than that of Fulani and Higgi found in this study in both sexes. Although the high mean values of FWLC found in Hausa population could be due to the age of the sampled population (18 years and above), because FWLC was found to increase with age (Ashbaugh, 1999; Cummins & Midlo, 1943) perhaps due to its correlation with body fat (Adamu et al., 2022). Genetic and physical activities might have also contributed; this is obvious in the current study because comparison was done between sampled populations of the same age category; therefore, the significant differences observed in this study could be explained based on genetic and physical activities. Several studies have found that the expression of obesity-related genes may predetermine the fingerprint pattern in obese people in utero (Cummins & Midlo, 1943). Body composition such as fat has been discovered to have a link with FWLC (Adamu et al., 2022), this is why female tend to have more white lines than male (Badawi et al., 2006; Tadorana et al., 2016; Adamu et al., 2019; Taura et al., 2019; Adamu et al., 2022). Any physical activity that is directly related to body fat might influence changes in FWLC. Considering culture and occupation, Higgi population is relatively more physically active than both Fulani and Hausa populations hence are likely to shed more fat than either. Hausa communities are relatively more accustomed to a sedentary lifestyle followed by Fulani and then Higgi. Sedentary daily life, according to Kaur and Deol (2021), is a type of lifestyle that involves little or no physical activity or exercise. This might be the reason why the mean values of FWLC is higher in Hausa followed by Fulani and least in Higgi. This is also supported by the findings of this study where only three out of ten fingers showed significant ethnic differences in male compared to all fingers except one in female due to the fact that the relative sedentary life is more pronounced in female than male. Thus, for male; only thumb, right middle and left little fingers can be used in determination of ethnic differences of Fulani and Higgi using fingerprint white lines. But for female, one can use any finger except the right ring finger in determination of ethnic differences of Fulani and Higgi using fingerprint white lines. Sexual

dimorphism in fingerprint white lines counts (FWLC) was found to exist in this study in both ethnic groups. FWLC were more common in female than male. In a study conducted on Hausa population, Females were equally found to have a significantly higher mean value of FWLC compared to males (Adamu et al., 2019; Taura et al., 2019; Adamu et al., 2022). In Philippines and different other populations, females were observed to have higher mean value of FWLC than male (Badawi et al., 2006; Tadorana et al., 2016). The differences might be as a result of relatively thin and denser ridges found in female (Atiku et al., 2018), it could also be as a result of genetic or hormonal influence. It has been observed that the level of prenatal hormones and a high level of testosterone in adult males were associated with dermatoglyphics asymmetry (Jamison et al., 1993; Richards, et al., 2022). It is not clear what exactly behind higher mean value of FWLC in left hand than right, and more common in thumb followed by ring and least in little finger. These trends exhibited the same pattern in both ethnic groups. Whatever the cause, variation of biological traits often provides additional information about an individual. Therefore, FWLC with sexual dimorphic features could be combined with other sex discriminating fingerprint features such as ridges thickness and ridges density for a better discrimination power than either alone. Some studies showed that absence of FWLC is indicative of male individual regardless of his ethnicity (Badawi et al., 2006; Tadorana et al., 2016; Adamu et al., 2019).

CONCLUSION

This study revealed ethnic differences and sexual dimorphism in fingerprint white lines of Fulani and Higgi tribes of Michika, Adamawa state, Nigeria. The fingerprint profile data generated in this study would be used as a reference data among Fulani and Higgi Ethnic groups of Adamawa state in forensic investigation.

Acknowledgements:

I would like to express my esteemed appreciation and gratitude to all the head teachers of the various schools for their cooperation, their examination officers and other staff for their support, the education secretary of Michika and the security personnel especially the military for their effort to ensure adequate security in the area.

Conflicts of Interest:

There are no conflicts of interest.

Source of Funding:

The research is a component of my PhD dissertation

Authors' contribution:

IAA: Designed and conducted the research. BD., LHA., and MT: Supervised the research from the beginning to the end and contributed immensely in the research design and data analysis. SSA and SAM: Contributed in the discussion of the findings.

Article History:

Received: 24th November 2024.

Accepted: 27th May 2025.

Published online: 31st May 2025.

REFERENCES

- Adamu, L. H., Asuku, A. Y., Muhd, U. A., Sa'id, T. L., Nasir, S. B., & Taura, M. G. (2019). Fingerprint white line counts: An upcoming forensic tool for sex determination. *Arab Journal of Forensic Sciences and Forensic Medicine*, 1(9), 1165-1173.
- Adamu, L. H., Nasir, S. B., Salisu, R., Rayyan, M. K., Muhd, U. A., Sa'id, T. L., Asuku, A. Y., and Taura, M. G. (2022). Fingerprints white line counts (fwLC): an unfolding panacea of body composition estimation among students of selected tertiary institution in Kano State Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, 8(2b), 53-62.
- Adebisi, S. S. (2008b). Fingerprint studies - The recent challenges and advancement: A literary review. *The Internet Journal of Biological Anthropology*, 2(2), <https://ispub.com/IJBA/2/2/9413>.
- Agnihotri, A. K., Jowaheer, V., & Allock, A. (2012). An analysis of fingerprint ridge density in the Indo-Mauritian population and its application to gender determination. *Medicine, Science and the Law*, 52(3), 143 – 147.
- Ahmed, A. A., & Osman, S. (2016). Topological variability and sex differences in fingerprint ridge density in a sample of the Sudanese population. *Journal of Forensic and Legal Medicine*, 42, 25–32.
- Ashbaugh, D. R. (1999). *Quantitative-qualitative friction ridge analysis: an introduction to basic and advanced ridgeology*. CRC Press LLC, Boca Raton, FL, <https://doi.org/10.1201/9781420048810>.
- Atiku, I. A., Taura, M. G., Yahaya, A. I., & Adamu, L. H., (2018). The role of fingerprints' ridge breadths in identification of sex and age estimation of the Hausa ethnic group in Nigeria, *Bayero Journal of Biomedical Sciences (BJBS)*, 3(1), 309 – 315
- Atiku, I. A., Adamu, L. H., & Isyaku, M. U. (2023). Prediction of age from fingerprint ridges density among Hausa ethnic group of Nigeria *Journal of Biomedical and Applied Sciences FUD*, 2(2), 7 – 16.
- Badawi, A., Mahfouz, M., Tadross, R., & Jantz, R. (2006). Fingerprint based gender classification. In: *The International Conference on Image Processing, Computer Vision, and Pattern Recognition*. CSREA Press, Las Vegas, NV.
- Cummins, H., & Midlo, C. (1943). *Finger prints, palms and soles: An introduction to dermatoglyphics*. Dover Publishing.
- Diouf, S. A. (2003). *Fighting the slave trade: West African strategies*. Ohio University Press.
- Eshak, G. A., Zaher, J. F., Hasan, E. I., El-Azeem, & Ewis, A. A. (2013). Sex identification from fingertip features in Egyptian population. *Journal of Forensic and Legal Medicine*, 20, 46–50. <https://doi.org/10.1016/j.jflm.2012.04.038>.
- Gutiérrez-Redomero, E., Alonso, C., Romero, E., & Galera, V., (2008). Variability of fingerprint ridges density in a sample of Spanish caucasians and its application to sex determination. *Forensic Science International*, 180, 17–22.
- Heine, B., & Derek N. (2008). *A linguistic geography of Africa*. Cambridge University Press.
- Jamison, C. S., Meier, R. J., and Campbell, B. C. (1993). Dermatoglyphic asymmetry and testosterone level in normal males. *American Journal of Physical Anthropology*, 90, 185-198. <https://doi.org/10.1002/ajpa.1330900205>.
- Kaur, P., & Deol, N.S. (2021). Assessment of body mass index and resting metabolism of male sedentary and active older adults of Punjab, India. *Laplace em Revista (International)*, 7(3), 552-564.
- Nayak, V. C., Rastogi, P., Kanchan, T., Yoganasimha, K., Kumar, G. P., and Menezes, R. G. (2010). Sex differences from fingerprint ridge density in Chinese and Malaysian population. *Forensic Science International*, 197(1-3), 67–69. <https://doi.org/10.1016/j.forsciint.2009.12.055>
- Nithin, M. D., Manjunatha, B., Preethi, D. S., & Balaraj, B. M. (2011). Gender differentiation by finger Ridge Density in South Indian population. *Journal of Forensic and Legal Medicine*, 18(2), 79–81.

- Noemí, R., Ángeles, S. A., Concepción A. R., José E. D., & Esperanza, G. R. (2015). Fingerprint ridge density in the Argentinean population and its application to sex inference: A comparative study. *HOMO-Journal of Comparative Human Biology*. journal homepage: www.elsevier.com/locate/jchb
- Reka, R. (2012). Automatic overlapped fingerprint separation. *International Journal of Computer Science and Information Technology and Security (IJSITS)*, 2(2), 286.
- Richards, G., Aydin, E., Tsompanidis, Padaigaitè, E., Austin, T., Allison, C., Holt, R. and Baron-Cohen, S. (2022). Digit ratio (2D:4D) and maternal testosterone-to-estradiol ratio measured in early pregnancy. *Scientific Report*, 12, 13586. <https://doi.org/10.1038/s41598-022-17247-3>.
- Rivaldería, N., Sánchez-Andrés, Á., Alonso-Rodríguez, C., Dipierri, J. E., & Gutiérrez-Redomero, E. (2016). Fingerprint ridge density in the Argentinean population and its application to sex inference: A comparative study. *Homo : internationale Zeitschrift für die vergleichende Forschung am Menschen*, 67(1), 65–84. <https://doi.org/10.1016/j.jchb.2015.09.004>.
- Saini M, Kapoor AK (2016). Biometrics in forensic identification: Applications and challenges. *Journal of Forensic Medicine*, 1(2): 108. doi: 1000108 10.4172/2472-1026.1000108
- Sharma, B. K., Walia, M., Sharma, S. C., Dhillon, D., Ishant and Mishra, N. K. (2022). Fingerprint Science: a review on historical and contemporary Forensic perspectives *Bulletin of Environment, Pharmacology and Life Sciences*, (5): 57 – 61
- Tadurana, R. J., Tadeo, A. K., Escalona, N. A., & Townsend, G. C. (2016). Sex determination from fingerprint ridge density and white line counts in Filipinos. *Homo : internationale Zeitschrift für die vergleichende Forschung am Menschen*, 67(2), 163–171. <https://doi.org/10.1016/j.jchb.2015.11.001>
- Taura, M. G., Adamu, L. H., Asuku, A. Y., Umar, K. B., & Abubakar, M. (2019). Adjacent digit fingerprint white line count differences: A Pointer to sexual dimorphism for forensic application. *Egyptian Journal of Forensic Sciences*, 9, 63. <https://doi.org/10.1186/s41935-019-0169-8>
- Van Beek, W.E.A (2012). *The dancing dead: Ritual and religion among the Kapsiki/Higi of North Cameroon and Northeastern Nigeria*. Oxford University Press, USA.
- Vinod C. et al. (2010). Sex differences from fingerprint ridges density in Chinese and Malaysian population. *Forensic Science International*. 197(1), 67-69.