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Research Article

The Variation of Ridge Density in Palm Prints among Nigerian Ethnic Populations and its Forensic Use for Sex Determination

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Abstract

Friction ridge skin has unique features that persist from before birth until decomposition after death. Finger and palm print identification is based on two primary factors: uniqueness and permanence. Ridge density (ridge count in a defined area) has been explored for its applicability in inference of sex from the fingerprints and palm prints recovered at the crime scene. In this study, we examined the variability of palm ridge density (PRD) from palm prints among Hausa, Igbo and Yoruba ethnic groups and its ability to infer sex in forensic examinations. The sample consisted of bilateral palm prints of 560 healthy adults (251 females and 309 males) from three ethnic groups in southwestern states. The prints were manually analyzed in four defined areas (PRD-1, PRD-2, PRD-3 and PRD-4) and the values aggregated. The ethnic and sex differences in palm print ridge densities were statistically analyzed for each of the designated areas. The mean (SD) aggregate PRD values of 11.49(1.48) for Hausa, 10.75(1.46) for Igbo and 11.71(1.64) for Yoruba; were significantly different ($p<0.05$) between the ethnic groups and significantly greater ($p<0.05$) in females than in males; 11.71(1.53) vs 9.93(1.02). The aggregate mean (SD) ridge densities were also significant different ($p<0.05$) between the right and left hands 11.09(1.05) and 9.33(1.14) respectively. This study showed significant differences in palm ridge densities among Nigerian major ethnic groups. There are also gender, right and left hand differences in this dermatoglyphic parameter. These results have forensic implications.

Key Words: *Palm ridge density, ethnic differentiation, sex differentiation*

INTRODUCTION

Dermatoglyphic patterns are useful in population studies because it is genetically determined, universal, permanent and its non-invasiveness in measurement. They are more phylogenetically stable than other biological variables (Karmakar *et al*, 2005). Its heritability is not confounded by environmental influences (Jantz, 1987; Muller-Ford, 2004; Machado, *et al*., 2010). Dermatoglyphs are formed between 4th and 19th week of embryogenesis and organogenesis (Cummings and Midlo, 1943) and patterns of dermatoglyphs formed during embryogenesis and organogenesis remain unchanged throughout the life of an individual. They are used to reconstruct biological human prehistory (Froehlich and Giles, 1981). Dermatoglyphic data can be used to estimate biological distance among ethnic populations using different categories of traits. Such distances are evaluated by comparing them to each other and to language and geographic distances (Crawford and Duggirala, 2014). Finger print identification is the most used in nature and the most extensively used technique in automatic personal identification. High resolution palm scanner are being used for safety measure at the entrances of sensitive sites as well as a means of identification for individuals (Zhou *et al*., 2001). It is also in use in a wide range of biometric applications. Dermatoglyphic traits can successfully distinguish monozygotic twins (Jain *et al*, 2002). Dermatoglyphic studies had been used to distinguish Chinese and Malaysian population and can be used as a presumptive indicator of gender of an unknown print left at a crime scene (Nayak V.C., 2010). Krishan *et al*., (2014) revealed that palm ridge density is a better trait for biological variability within individuals and among populations than other polymorphic traits such as eye color and blood type. Dermatoglyphs has been proposed as possible markers for identification of potential female criminals in a studied population (Ozor-Nwafia, *et al*, 2018). In a study among North Indians to identify gender using ridge density, latent palm print showed that females had a greater ridge density than males (Amit, Singh and Kushwaha, 2015) while sex and stature were determined by the use of latent palm prints on documents from Egypt populations. In a central Indian population, females were shown to tend to have a higher thumbprint ridge density than males suggesting that this can be a forensic tool for the determination of gender in cases where only partial thumbprints are encountered at a crime scene or on documents (Kapoor and Badiye, 2015). Palm print ridge density was shown to be an effective tool in inference of sex among the north Indians (Krishan, *et al*, 2014) and among the Spanish population (Gutiérrez-Redomero and Alonso-Rodríguez, 2013) as well as in other populations. What is the predictability of this variable in sex estimation among Nigeria ethnic populations?

This study was designed to quantify the palmar print density characteristics of the three Nigerian ethnic groups and to determine its effectiveness in sex determination among Nigeria ethnic groups.

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MATERIALS AND METHODS

A sample size of 175 for Hausa, 163 for Igbo and 222 for Yoruba ethnic groups based on ethnic volunteers' that meet the inclusion criteria: age of 18years and above, descendants of parents, grandparents and great grandparents who come from the same ethnic groups and the appropriate zones of the country; Hausa from states of northwest zone, Igbo from states of southeast zone and Yoruba from states of southwest zone of Nigeria.

Consent was obtained on a form signed or thumb printed in the presence of a witness. The volunteer's hands were cleaned with soap and water in order to remove dirt and dust, and wiped dry with a towel. A small amount of diluted printer's ink was spread on the glass slab thoroughly with the help of a roller large enough to accommodate the whole hand from proximal wrist crease to the tip of the middle finger and the lateral margin of the thumb to the medial border of the palm. The whole hand, left first, was placed on the inked slab. A foam was used to spread the ink to areas of the hand that did not make contact with the slab from near the tips of the fingers to the level of the proximal wrist crease.

A piece of A4 glossy paper was placed on an evenly smooth table top. The left hand was first placed on the glossy paper from the wrist end, then the radial side of the palm, the central part of the palm, the ulnar side with all the fingers fully extended. The thumb and fingers 2, 3, 4 and 5 were rolled from the radial side to the ulnar. Gentle pressure was applied to the areas of the hand that did not touch the paper surface. The hand was carefully removed from the surface of the paper starting from the tip of the fingers in a proximal direction without smearing of the print. The paper was held down by an assistant while the researcher assisted the volunteer to gently lift the hand from the print. A similar process was then applied to the right hand. The print was allowed to dry before storage in a labelled paper envelope.

The prints were read with 4X Power Acrylic Lens Flexible Arm Lighted Magnifier (Power Bifocal Margin Lamp Magnifier). The palm print areas were analyzed for the palm ridge density (PRD) according to Krishan *et al*. (2014). The variables for both hands were counted for each volunteer from predefined areas of the palm prints of the right (R) and left (L) hands determined as follows (Plate 1):

PRD-1 - midpoint of line on thenar eminence connecting mid first metacarpophalangeal crease and mid-distal wrist crease.

PRD-2 - a point on hypothenar eminence midpoint of straight line connecting mid of fifth metacarpophalangeal crease and mid distal wrist crease.

PRD-3 - a point half centimeter proximal to triradius "a".

PRD-4 - a point half centimeter proximal to triradius "d".

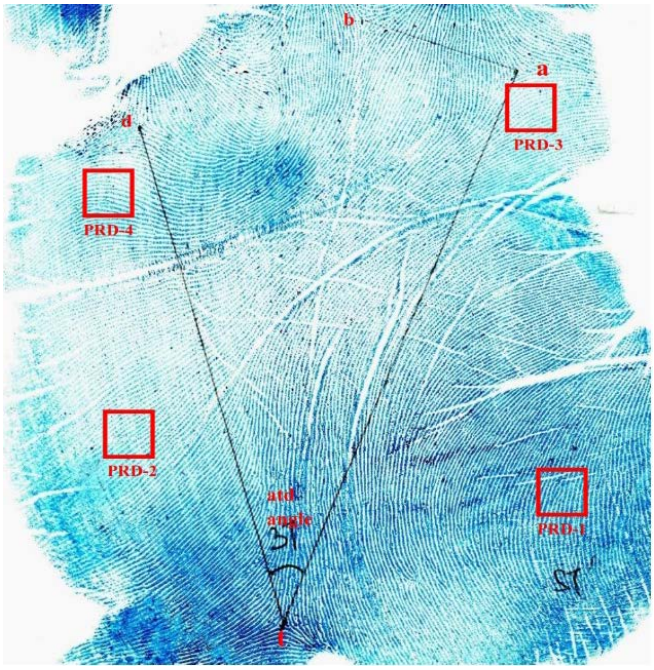

Plate 1
Palmar print of left hand showing areas on the print analysed for the palm ridge density, delta t and the atd angle deltas a and b.

A 25mm^2 area was drawn on the defined areas (Acree 1999). The ridges in 25mm^2 area was counted to reflect the ridge density count. The variables for both hands were counted for all volunteer

The study was approved by the Research Ethics Committee of the Oyo State of Nigeria Ministry of Health and only participants who gave their informed consent were involved in the study. Software package for statistical analysis (SPSS 20) was used for analysis of variance (ANOVA), post-hoc tests for gender differences within population and among ethnic populations. T- test was used to investigate gender difference. The level of confidence was set at 95%.

RESULTS

The mean (SD) Palm Ridge Densities -1,2,3,4 are shown in Table 1. Palm ridge density varies in right and left hand of an individual. PRD-3 has highest value among the three ethnic groups while PRD-1 has the lowest value, however, there is a considerable overlap of male and female values in palm ridge densities of defined areas of both right and left hand.

Table 1:
Palmar Dermatoglyphic differences among three ethnic Populations

	Hausa **(n= 175)**		Igbo **(n = 163)**		Yoruba **(n = 222)**	
Parameter	Right	Left	Right	Left	Right	Left
PRD-1	11.42±1.56[a]	10.15±1.39[a]	10.20±1.80[b]	9.24±1.38	10.73±1.73[c*]	9.94±1.49[c*]
PRD-2	11.40±1.51[a]	11.86±1.38[a]	10.58±1.33[b]	10.73±1.12[b]	11.55±1.42[c*]	11.84±1.70[c*]
PRD-3	12.34±1.60	12.71±1.39[a]	11.53±1.32[b]	11.76±1.39[b]	13.05±1.62[c*]	13.15±1.69[c*]
PRD-4	10.95±1.48[a]	10.88±1.55[a]	10.89±1.64[b]	11.13±1.67[b]	11.68±1.73[c*]	11.74±1.75[c*]

PRD-1, 2, 3, 4, Palmar ridge density 1,2,3,4.
[a] = Post-Hoc test (H vs I) (P<0.05)
[b] = Post-Hoc test (I vs Y) (P<0.05)
[c] = Post-Hoc test (H vs Y) (P<0.05)
[*] = ANOVA P value (P<0.05)

Table 2:
Palmar Dermatoglyphic gender differences within the ethnic populations

	Hausa				Igbo				Yoruba			
	Female		Male		Female		Male		Female		Male	
	n=52		n=123		n=44		n=119		n=155		n=67	
Variable	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
PRD-1	11.86 ±1.40	10.43 ±1.30	11.23 ±1.59	10.02 ±1.40*	10.38 ±2.23	9.58 ±1.44	10.14 ±1.62	9.11 ±1.34*	11.03 ±1.76	10.17 ±1.43	9.98 ±1.43	9.38 ±1.50*
PRD-2	11.41 ±1.65	12.20 ±1.34	11.38 ±1.46	11.72 ±1.39	11.26 ±1.26	11.14 ±1.06	10.33 ±1.28	10.58 ±1.11*	11.76 ±1.16	12.14 ±1.58	11.06 ±1.20	11.11 ±1.81*
PRD-3	13.00 ±1.60	13.31 ±1.19	12.05 ±1.52	12.44 ±1.39*	12.02 ±1.46	12.35 ±1.63	11.35 ±1.22	11.54 ±1.22*	13.23 ±1.66	13.47 ±1.65	12.61 ±1.45	12.38 ±1.55*
PRD-4	11.24 ±1.39	11.27 ±1.31	10.86 ±1.49	10.73 ±1.61*	11.44 ±1.80	11.80 ±1.99	10.68 ±1.54	10.90 ±1.48*	11.70 ±1.70	11.85 ±1.68	11.62 ±1.82	11.46 ±1.90

PRD-1,2,3,4, *Palmar ridge density at points 1, 2, 3 and 4 on the palm*
* *significant T-Test P values (P<0.05) between gender, right and left within ethnic population*

Statistically significant differences (p<0.05) in the palm ridge densities between both hands were observed in the three ethnic groups. PRD-1 showed significant ethnic differences for the Hausa and Igbo ethnic groups on both hands; Igbo and Yoruba significant ethnic difference on PRD-1 was on the right hand only; Hausa and Yoruba ethnic difference was shown by PRD-1 on both hands. In both hands, PRD-2 was similar between Yorubas and Hausa, while the Ibos were different from both of them. PRD-3 showed significant ethnic differences on both palms for the three ethnic groups. PRD-4 revealed ethnic differences between Hausa and Yoruba in both palms, Igbo and Hausa on the (L) palm (p<0.05).

The mean (SD) of Palm Ridge Density -1,2,3,4 gender differences within the ethnic populations was shown in Table 2. PRD-1 showed sexual dimorphism within Yoruba and Hausa ethnic groups.

PRD-2 showed sexual dimorphism within Yoruba and Igbo ethnic groups but no sexual dimorphism within the Hausa ethnic sample. Female had significantly higher PRD-3 count within the three ethnic groups and also showed sexual dimorphism among the three ethnic groups. Female had significantly higher PRD-4 among the Hausa and Igbo ethnic groups but no sexual difference in PRD-4 within Yoruba group.

The comparison of aggregate palmar ridge density values (Table 3) revealed significant differences (p<0.05) among the three ethnic groups. Right hand had significantly higher value (p<0.05) than the left. Females have significantly higher value (p<0.05) than the males.

Table 3:
The comparison of aggregate Palmar Ridge density values

Ethnic groups	Hausa	Igbo	Yoruba
	N=175	N=163	N=222
PRD	11.49±1.48	10.75±1.46	11.71±1.64**

All Ethnic groups	Right Hand	Left Hand
	11.09±1.05	9.33±1.14*
	Female	**Male**
	11.71±1.53	9.93±1.02*

PRD, Palm Ridge Density
** Anova p< 0.05 * T- Test p< 0.05

DISCUSSION

This study showed that the palm ridge density varies in the predefined areas. The ridge density is also found to vary in both hands of an individual. It suggested that the palm ridge density shows bilateral variations. The palmar prints showed significant differences between the three ethnic populations. Palm prints can be recovered as latent prints from crime scenes and there are always needs for analysis and identification. This result showed that it is possible to narrow down the search by quantitatively analyzed recovered print and use it in conjunction with other parameters to suggest the ethnic group of the subject. There are studies that have shown variability of finger and palmar prints in human populations (Jantz and Owsley, 1977; Jantz and Parham, 1978; Mi *et al*., 1982; Stoney and Thornton, 1986; Moore, 1994; Jantz, 1997). Palm prints features that characteristically distinguish it from fingerprint is the presence of larger skin area and other discriminative features such as principal lines and creases with bifurcations, enclosures and variations in point of joining at lateral edges which can be used as important adjunct in identification (Adetona, Oladapo and Akinyemi, 2012). Jain and Feng (2009), had shown that about 30% of the latent prints recovered from crime scenes are from palms thus palm print analysis and establishment of its databases has a considerable potential for personal and ethnic group identification.

The PRD showed sexual dimorphism within the three ethnic populations. The PRD had been shown to effectively reveal sexual dimorphism in other human population studies (Nayak *et al*., 2010; Krishan *et al*., 2014). Females have finer epidermal ridge details than males (Gutiérrez-Redomero *et al*., 2013b). Ridge density is determined by the width of the ridge, the distance between ridges and the thickness of the epidermal ridges (Gutiérrez-Redomero *et al*., 2011). The finer ridges of females account for the greater ridge density in females than the males (Gutiérrez-Redomero *et al*., 2011). The sex differences in palm print ridge density may be a useful preliminary means of distinguishing male and female identity in cases of mass disasters and identification of dismembered human forelimb parts.

This study showed significant differences in palm ridge densities among Nigerian major ethnic groups. Ridge density can be used to infer sex among these populations, in conjunction with other quantifiable phenotypic characters. This study highlighted significant right and left hand

differences in palm ridge density. These results have identification and forensic implications.

REFERENCES

Abd-elaleem S.A., Hassan E.I., Asem Mohammed M.M. 2017. Determination of Sex and Stature from Latent Palm Prints Present on Documents in Egyptian Population Sample. Int J Forensic Sci Pathol. 5(4), 360-369.

Adetona, Oladapo and Akinyemi. 2012. Palmar Flexion Creases Variants among Nigerians. Afr. J. Biomed. Res. 15: 93 – 96.

Acree, M. A. 1999. Is there a gender difference in fingerprint ridge density? Forensic science international, 102(1), 35-44.

Amit C., Singh J., Kushwaha K.P. 2015. An evaluation: sexing from the ridge density of latent palm prints of North Indian Population. Res J Recent Sci. 4: 73-75.

Crawford, M.H., Duggirala, R. 1992. Digital dermatoglyphic patterns of Eskimo and Amerindian populations: Relationships between geographic, dermatoglyphic, genetic, and linguistic distances. Human Biology 64(5): 683-704.

Cummins, H., Midlo, C. 1943. Finger prints, palms and soles. An introduction to Dermatoglyphics. 1st ed. Dover Publications, Inc. New York.

Froehlich, J.W., Giles, E. 1981. A multivariate approach to fingerprint variation in Papua New Guinea: Perspectives on the evolutionary stability of dermatoglyphic markers American Journal of Physical Anthropology 54(1): 93–106.

Gutiérrez-Redomero, E., Alonso, M. C., Dipierri, J. E. 2011. Sex differences in fingerprint ridge density in the Mataco-Mataguayo population. Homo, 62(6), 487-499.

Gutiérrez-Redomero, E., Sánchez-Andrés, A., Rivaldería, N., Alonso-Rodríguez, C., Dipierri,

J.E., Martín, L.M., 2013a. A comparative study of topological and sex differences in fingerprint ridge density in Argentinian and Spanish population samples. J. Forensic Leg. Med. 20: 419–429.

Jain, A. K., Prabhakar, S., Pankanti, S. 2002. On the similarity of identical twin fingerprints. Pattern Recognition, 35(11), 2653-2663.

Jain, A. K., Feng, J. 2009. Latent palmprint matching. IEEE Transactions on pattern analysis and machine intelligence, 31(6), 1032-1047.

Jantz R.L. 1987. Anthropological Dermatoglyphic Research. Annual Reviews of Anthropology 16:161-77.

Jantz R.L. 1997. Variation among European populations in summary finger ridge-count variables, Ann. Hum. Biol. 24(2): 97–106.

Jantz R.L., Owsley D.W. 1977. Factor analysis of finger ridge-counts in Blacks and Whites Ann. Hum. Biol. (4): 357–366.

Jantz R.L., Parham K.R. 1978. Racial differences in dermal ridge breadth, Hum. Biol. 50(1):33–40.

Karmakar, B., Malkin, L., Kobyliansky, E. 2005. Asymmetry and Diversity of Dermatoglyphic traits: Population comparison in five endogamous groups of West Bengal, India. Anthropologischer Anzeiger, 365-391.

Kapoor, N., Badiye, A. 2015. Sex differences in the thumbprint ridge density in a central Indian population. Egyptian Journal of Forensic Sciences, 5(1), 23-29.

Krishan, K., Kanchan, T., Sharma, R., Pathania, A. 2014. Variability of palmprint ridge density in a North Indian population and its use in inference of sex in forensic examinations.

HOMO-Journal of Comparative Human Biology, 65(6), 476-488.

Machado, J. F., Fernandes, P. R., Roquetti, R. W., Fernandes Filho, J. 2010. Digital dermatoglyphic heritability differences as evidenced by a female twin study. Twin Research and Human Genetics 13(05): 482-489

Mi M.P., Budy A.M., Rashad M.N. 1982. A population study of finger dermal patterns and ridge counts, in: C.S. Bartsocas (Ed.). Progress In Dermatoglyphic Research, Alan R. Liss, New York, pp. 285–293.

Moore R.T. 1994. Automatic fingerprint identification systems, in: H.C. Lee, R.E. Gaensslen (Eds.), Advances in Fingerprint Technology, CRC Press, Boca Raton, FL, pp. 164–191.

Muller-Ford, C. S. 2004. Analysis of dermatoglyphic heritability: A study of phenotypic relationships. Theses, Dissertations, Professional Papers. Paper 6393.

Nayak, V.C., Rastogi, P., Kanchan, T., Yoganarasimha, K., Kumar, G.P., Menezes, R.G. 2010. Sex differences from fingerprint ridge density in Chinese and Malaysian population. Forensic Science International 197: 67–69.

Ozor Nwafia C.P., Emelobe C.S.., Igbigbi P.S., Ozor C.K. 2018. Dermatoglyphic patterns of female convicted criminals in Anambra state. Forensic Res Criminol Int J.. 2018;6(4):294–296.

Stoney D.A., Thornton J.L. (1986). A method for the description of minutia pairs in epidermal ridge patterns. J. Forensic Sci. (31): 1217–1234.

Zhou, Y., Zeng, Y., Hu, L., Hu, W. 2001. Application and development of palm print. Research. Technology and Health Care 10 (2002) 383–390