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Dermatoglyphics of the Sickle Cell Anemic (HbSS) and Normal (HbAA) Subjects: A Comparative Study of the Sub-Saharan African Population .

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ABSTRACT

Dermatoglyphics have a very wide range of application as in human identification, security purposes and predicting the future phenotype of diseases. Sickle cell anaemia is a very prevalent blood disorder, but there is no baseline data on dermatoglyphics of the people living with the condition among the Hausa ethnic group of Kano. The study was conducted in Murtala Muhammed Specialist Hospital Kano, in which the fingerprint features of 200 people living with sickle cell Anaemia were compared to 200 normal individuals. The frequency of fingerprint patterns, fingerprint ridge density in a $25mm^2$, and fingerprint ridge thickness were studied. An application system was used to capture the fingerprints through a fingerprint scanner device connected to the computer system via USB. Both radial and ulnar ridge density and thickness were obtained by the application. Independent sample *T-test* was used to compare the ridge density and thickness of the sickle cell patients and that of the normal group. Chi-square test was used to determine association between fingerprint patterns and sickle cell anaemia. The results showed no significant association between sickle cell anaemia and fingerprint patterns of all the digits of both hands in both sexes. However, people living with sickle cell anaemia were found to have higher ridge density than the normal group with significant difference seen in some of the digits in both sexes. Similarly, normal individuals had higher mean ridge thickness with significant difference seen in some of the digits in both sexes. The study showed that specific differences exist between people living with sickle cell anaemia and normal group and the data obtained can serve as a baseline for the fingerprint features of people living with sickle cell anaemia in Kano.

Keywords: Sickle cell Anaemia, Control, Dermatoglyphics, Comparison, Kano, Nigeria

INTRODUCTION

Dermatoglyphics is a science of studying the patterns of skin ridges present on the fingers, palm, toes, and the soles[1] and its importance for purposes of personal identification dates to 1880[2]. Its utility is not restricted to biometric identification and crimes investigation but also serves as genetic markers in diagnosis of medical and genetic disorders[3],[4]. The dermatoglyphic patterns are formed under combination of genetic and environmental factors and configurations are permanent after the sixth month of prenatal life[5,6]. During this crucial period, the ridges may form in some abnormal patterns, thus used in as useful tool in diagnosis of disease[7,8]. Previous studies confirm that there is a relation between dermatoglyphics and some diseases, such as schizophrenia, coronary artery disease, Multiple Sclerosis, & type 1 diabetic mellitus[9,10]. In addition, dermatoglyphics serves as a tool to describe, compare, and to predict occurrence and risk for biomedical events[11].

Sickle cell anaemia on the other hand, is a recessive genetic blood disorder caused by defect in the gene which codes for haemoglobin. The defective gene is haemoglobin S, which changes the shape of red blood cell to crescent or sickle shaped. The affected red blood cells are prone to haemolysis and phagocytosis by reticuloendothelial system leading to haemolytic anaemia and jaundice[12]. The recurrent pain and complications caused by the disease can interfere with many aspects of the patient's life, including education, employment, and psychosocial development[13]. The sickle-cell trait is now known to be widespread, reaching its highest prevalence in parts of Africa as well as among people with origins in equatorial Africa, the Mediterranean basin, and Saudi Arabia. In countries, such as Nigeria, Cameroon, Republic of Congo, Gabon, and Ghana the prevalence is between 20% and 30% while in some parts of Uganda it is as high as 45%[13].

Dermatoglyphics may represent the genetic makeup of an individual and therefore their predisposition to certain diseases. Understanding the dermatoglyphics of sickle cell anaemia patients will offer a better understanding of the disease. This may also provide a useful database of sickle cell anaemia associated dermatoglyphic for other applications such as in wide scale epidemiological screening and personal identification. The aim of this study was to compare

the fingerprint features between the sickle cell anaemia patients with normal subjects among population of Kano state, Nigeria.

MATERIALS AND METHODS

The study was conducted on patients attending sickle cell anaemia clinic in Murtala Muhammad specialist Hospital (MMSH). This hospital is located within the metropolis of Kano state, Northwest of Nigeria. A total of 200 sickle cell patients with HbSS genotype (99 males and 101 females) and 200 subjects with HbAA genotype (111 males and 89 females) were screened for the dermatoglyphic analyses. All the participants were from Hausa ethnic group in which their ages ranged between 18-25 years. Ethical approval was obtained from Kano state Hospitals Management Board. Informed consent was also gained from the participants before participation. The study was conducted in accordance with Helsinki declaration.

The fingerprints were captured using an electronic scanner (digita persona, China) connected to a computer. The image was saved using in-house customized software developed using MS visual basic programming language (version 6) onto the computer hard drive.

The fingerprints were classified as arches, whorls, ulnar loop, and radial loop patterns
(Plate 1). The ridge density (RD) was obtained as per the method described by Acree[14] and modified by Gutiérrez-Redomero *et al.*[15] The ridge count was done diagonally on a square measuring 5mm×5mm ($25mm^2$). RD was obtained as the number of ridges counted per $25mm^2$ (Plate 2). The mean ridge thickness (MRT) was determined by dividing the length of the diagonal which, according to Pythagoras theorem is = $\sqrt{(5^2+5^2)}$ by the number of ridges counted along the diagonal (RD) as proposed by Penrose (1968). Thus, MRT=$\sqrt{(5^2+5^2)} \div$ RD. The reliability and validity of the methods were also reported elsewhere in the literature[16, 17].

Plate 1: Fingerprint patterns

Plate 2: Determination of fingerprint ridge density

The data were expressed as mean ± standard deviation and range (minimum and maximum). Independent sampled t test was used to determine the differences in RD and MRT between the patients and control. Association of fingerprint pattern with sickle cell patients was determine using Pearson's chi square test. The data were analysed using the Statistical Package for Social Sciences (SPSS) software version 20. $P < 0.05$ was considered as level of significance.

RESULTS

In the right hands of MALES with normal genotype (HbAA) and those with sickle cell anaemia (HbSS), the thumb was predominantly whorl pattern, whereas the rest of the digits were dominated by ulnar loop. However, in the left-hand, ulnar loop was the most prevalent pattern in the thumb and all other digits of both HbAA and HbSS subjects, except the thumbs of HbAA subjects which were whorl (Table 1). The thumbs of both left and right hands of HbAA FEMALE subjects, and the left ring fingers were predominantly whorl pattern, whereas the thumbs of HbSS and the rest of the digits of both HbSS and HbAA subjects were dominated by ulnar loop in both left and right hands (Table 2). However, when Chi-square test was conducted, there was no statistically significant differences between the print patterns seen in all the thumbs and other digits of both left and right Hands in either male or female HbAA and HbSS subjects (Tables 1 & 2).

Table 1: Association between HbSS and HbAA male subjects' dermatoglyphics of the right hand

Side	Digits	Groups	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)		P-Value
Right	Thumb	HbAA	6(40)	3(50)	37(45.1)	53(49.5)	0.7060	0.8720
		HbSS	9(60)	3(50)	45(54.9)	54(50.5)		
	Index	HbAA	7(38.9)	9(64.3)	48(46.2)	35(47.3)	2.1850	0.5340
		HbSS	11(61.1)	5(35.7)	56(53.8)	39(52.7)		
	Middle	HbAA	10(45.5)	2(50)	60(44.4)	27(55.1)	1.6780	0.6420
		HbSS	12(54.5)	2(50)	75(55.6)	22(44.9)		
	Ring	HbAA	3(33.3)	3(60)	39(43.3)	54(50.9)	2.1590	0.5400
		HbSS	6(66.7)	2(40)	51(56.7)	52(49.1)		
	Little	HbAA	3(60)	3(18.8)	76(50.3)	17(44.7)	6.2120	0.1020
		HbSS	2(40)	13(81.3)	75(49.7)	21(55.3)		
Left	Thumb	HbAA	6(35.3)	7(77.8)	41(44.6)	45(48.9)	4.7080	0.1940
		HbSS	11(64.7)	2(22.2)	51(55.4)	47(51.1)		
	Index	HbAA	9(34.6)	7(53.8)	40(41.7)	43(57.3)	6.1530	0.1040
		HbSS	17(65.4)	6(46.2)	56(58.3)	32(42.7)		
	Middle	HbAA	8(34.8)	5(100)	52(43)	34(55.7)	9.6680	0.2200
		HbSS	15(65.2)	0 (0)	69(57)	27(44.3)		
	Ring	HbAA	6(66.7)	2(100)	53(45.3)	38(46.3)	3.8000	0.2840
		HbSS	3(33.3)	0(0)	64(54.7)	44(53.7)		
	Little	HbAA	6 (60)	3(50)	63(42.9)	27(57.4)	3.7690	0.2870
		HbSS	4 (40)	3(50)	84(57.1)	20(46.4)		

Table 2: Association between HbSS and HbAA female subjects' dermatoglyphics of the right hand

Side	Digits	Groups	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	$\chi 2$	P-Value
Right	Thumb	HbAA	9(52.9)	6(66.7)	30(41.7)	56(60.9)	6.675	0.0830
		HbSS	8(47.1)	3(33.3)	42(58.3)	36(39.1)		
	Index	HbAA	10(45.5)	4(36.4)	44(50)	43(62.3)	4.448	0.2170
		HbSS	12(54.5)	7(63.6)	44(50)	26(37.7)		
	Middle	HbAA	4(30.8)	4(80)	70(55.1)	23(51.1)	4.335	0.2270
		HbSS	9(69.2)	1(20)	57(44.9)	22(48.9)		
	Ring	HbAA	4(66.7)	2(66.7)	48(50)	47(55.3)	1.2	0.7530
		HbSS	2(33.3)	1(33.3)	48(50)	38(44.7)		
	Little	HbAA	4(80)	1(33.3)	87(56.1)	9(33.3)	6.731	0.2190
		HbSS	1(20)	2(66.7)	68(43.9)	18(66.7)		
Left	Thumb	HbAA	12(66.7)	3(60)	39(45.3)	47(58)	4.29	0.2320
		HbSS	6(33.3)	2(40)	47(54.7)	34(42)		
	Index	HbAA	6(31.6)	7(53.8)	49(51.6)	39(61.9)	5.5860	0.1340
		HbSS	13(68.4)	6(46.2)	46(48.4)	24(38.1)		
	Middle	HbAA	10(52.6)	3(100)	56(51.4)	32(54.2)	2.812	0.2200
		HbSS	9(47.4)	0(0)	53(48.6)	27(45.8)		
	Ring	HbAA	1 (100)	3(60)	47(46.5)	50(60.2)	4.4270	0.2190
		HbSS	0(0)	2(40)	54(53.5)	33(39.8)		
	Little	HbAA	1(33.3)	2(40)	87(56.1)	12(41.4)	3.0090	0.0810
		HbSS	2(66.7)	3(60)	68(43.9)	17(58.6)		

Table 3: Comparison of ridge density of people living with sickle cell anaemia and the Mean ± SD (Female)

		Mean ± SD (Male)				Mean ± SD (Female)			
Side	Digit	HbAA	HbSS	T	P-Value	HbAA	HbSS	T	P-Value
RURD	Thumb	9.7 ± 1.3	9.7 ± 1.4	-0.58	0.953	10.3 ± 1.4	9.8 ± 1.2	-2.353	0.020
	Index	11.1 ± 1.4	10.8 ± 1.5	-1.356	0.177	11.3 ± 1.2	10.9 ± 1.4	2.225	0.027
	Middle	10.2 ± 1.3	10.3 ± 1.4	0.633	0.527	10.7 ± 1.3	10.0 ± 1.3	-3.330	0.001
	Ring	10.5 ± 1.5	10.2 ± 1.6	-1.322	0.184	10.5 ± 1.5	10.3 ± 1.4	-1.288	0.199
	Little	11.3 ± 1.5	10.6 ± 1.3	-3.743	0.001	11.2 ± 1.4	10.7 ± 1.2	-2.478	0.140
LURD	Thumb	9.7 ± 1.4	9.8 ± 1.7	-0.484	0.629	9.9 ± 1.3	10.2 ± 1.3	-1.389	0.166
	Index	10.6 ± 1.5	11.2 ± 1.4	-2.38	0.005	11.3 ± 1.4	11.3 ± 1.3	-0.220	0.826
	Middle	10.4 ± 1.5	10.7 ± 1.4	-1.417	0.158	10.1 ± 1.3	10.6 ± 1.4	-2.289	0.025
	Ring	10.4 ± 1.4	10.6 ± 1.4	-0.727	0.468	10.2 ± 1.3	10.5 ± 1.5	-1.578	0.116
	Little	10.6 ± 1.3	10.9 ± 1.3	-1.896	0.059	10.6 ± 1.1	11.8 ± 1.4	-5.920	0.001
RRRD	Thumb	10.0 ± 1.1	10.1 ± 1.3	0.121	0.904	10.0 ± 1.3	9.9 ± 1.4	-0.308	0.758
	Index	11.1 ± 1.3	10.7 ± 1.5	-2.161	0.032	10.9 ± 1.2	11.3 ± 1.4	-2.225	0.027
	Middle	10.3 ± 1.2	10.3 ± 1.3	0.347	0.729	10.5 ± 1.3	10.2 ± 1.4	-1.631	0.105
	Ring	10.6 ± 1.4	10.2 ± 1.4	-1.925	0.560	10.6 ± 1.4	10.1 ± 1.4	-2.098	0.037
	Little	11.4 ± 1.2	10.6 ± 1.3	-4.382	0.001	11.2 ± 1.5	10.9 ± 1.2	-1.811	0.072
LRRD	Thumb	9.9 ± 1.3	9.8 ± 1.3	-0.328	0.743	9.9 ± 1.5	10.1 ± 1.2	-0.957	0.340
	Index	11.1 ± 1.3	11.3 ± 1.3	1.378	0.170	11.2 ± 1.5	11.1 ± 1.2	0.4320	0.666
	Middle	10.7 ± 1.4	10.4 ± 1.5	-1.438	0.152	10.1 ± 1.4	10.6 ± 1.3	-2.2492	0.059
	Ring	10.6 ± 1.3	10.2 ± 1.4	-1.873	0.063	10.2 ± 1.4	10.5 ± 1.4	-1.510	0.133
	Little	10.6 ± 1.4	10.6 ±1.5	-0.218	0.828	10.8 ± 1.1	11.1 ± 1.4	1.413	0.159

Table 3 shows comparison of both left and right ulnar and radial ridge densities of both left and right Hands. In the MALES, right radial ridge density (RRRD) was significantly greater than 11.0 ($P<0.05$) in both index and little fingers of HbAA subjects (HbSS subjects: < 11.0), and right ulnar ridge density (RURD) was also significantly greater than 11.0 ($P<0.05$) in the little fingers of the same HbAA subjects (HbSS subjects: < 11.0). However, left ulnar ridge density (LURD) of the index fingers of HbSS was significantly greater than 11.0 (HbAA subjects: < 11.0) with $P<0.05$.

In the FEMALE, individuals with HbAA genotype had a significantly higher RURD than individuals with HbSS genotype ($P<0.05$) in the thumb, index and middle fingers. However, HbSS subjects had significantly higher LURD than HbAA subjects ($P<0.05$) but in the middle and little fingers only. Similarly, HbSS subjects had significantly higher RRRD than HbAA subjects ($P<0.05$) in the little fingers only, whereas, HbAA subjects had significantly higher RRRD ($P<0.05$) in the ring fingers (Table 3).

Table 4: Comparison of mean ridge thickness of people living with sickle cell anaemia and the control group based on sex

		Mean ± SD (Male)				Mean ± SD (Female)		T	P-Value
Side	Digit	HbAA	HbSS	T	P-Value	HbAA	HbSS		
RURT	Thumb	0.74 ± 0.04	0.74 ± 0.14	-0.150	0.8810	0.70 ± 0.11	0.72 ± 0.09	1.764	0.790
	Index	0.65 ± 0.10	0.67 ± 0.10	1.436	0.1530	0.661 ± 0.66	0.63 ± 0.06	-1.964	0.051
	Middle	0.70 ± 0.10	0.70 ± 0.11	-0.292	0.7700	0.67 ± 0.10	0.72 ± 0.10	3.350	0.001
	Ring	0.68 ± 0.10	0.70 ± 0.13	0.727	0.4680	0.70 ± 0.10	0.70 ± 0.10	1.035	0.302
	Little	0.64 ± 0.10	0.68 ± 0.10	3.222	0.0010	0.64 ± 0.10	0.67 ± 0.08	2.047	0.420
LURT	Thumb	0.74 ± 0.14	0.73 ± 0.11	-0.042	0.9670	0.71 ± 0.15	0.72 ± 0.09	0.563	0.166
	Index	0.64 ± 0.10	0.68± 0.10	2.622	0.0090	0.63 ± 0.10	0.644±0.09	0.333	0.739
	Middle	0.67 ± 0.10	0.69 ± 0.11	1.431	0.1540	0.68 ± 0.11	0.71 ± 0.10	1.897	0.059
	Ring	0.68 ± 0.10	0.69 ± 0.10	0.724	0.4700	0.68 ± 0.09	0.70 ± 0.10	1.749	0.082
	Little	0.66 ± 0.09	0.68 ± 0.09	1.677	0.0950	0.61 ± 0.08	0.67 ±0.08	5.186	0.001
RRRT	Thumb	0.71 ± 0.08	0.72 ± 0.11	0.179	0.8580	0.72 ± 0.11	0.72 ± 0.11	0.342	0.733
	Index	0.64 ± 0.09	0.68 ± 0.10	2.370	0.1900	0.65 ± 0.08	0.65 ± 0.10	0.301	0.764
	Middle	0.70 ± 0.08	0.70 ± 0.10	-0.123	0.9020	0.68 ± 0.09	0.70 ± 0.10	1.263	0.208
	Ring	0.68 ± 0.10	0.70 ± 0.10	1.750	0.0820	0.68 ± 0.10	0.71 ± 0.10	2.133	0.037
	Little	0.63 ± 0.07	0.68 ± 0.09	4.279	<0.001	0.64 ± 0.01	0.66 ± 0.01	1.265	0.207
LRRT	Thumb	0.73 ± 0.10	0.73 ± 0.11	0.535	0.5930	0.71 ± 0.10	0.73 ± 0.12	1.400	0.163
	Index	0.65 ± 0.09	0.63 ± 0.08	-1.345	0.1800	0.64 ± 0.08	0.64 ± 0.10	-0.316	0.753
	Middle	0.67 ± 0.11	0.69 ± 0.11	1.381	0.1690	0.67 ± 0.10	0.71 ± 0.11	2.352	0.020
	Ring	0.68 ± 0.09	0.70 ± 0.10	1.912	0.0570	0.69 ± 0.01	0.71 ± 0.10	1.441	0.151
	Little	0.68 ± 0.10	0.68 ± 0.11	0.225	0.8220	0.64 ± 0.01	0.66 ± 0.08	1.527	0.129

Right Ulnar Ridge Density (RURD), Left Ulnar Ridge Density (LURD), Right Radial Ridge Density (RRRD), Left Radial Ridge Density (LRRD)

Regarding ridge thickness of all the fingers in MALES, RURT and RRRT are found to be only significantly more (P<0.05) in the little fingers of the HbSS than in HbAA subjects. However, LURT was found to be significantly more (P<0.05) in the index fingers of HbSS than in the HbAA subjects. In the FEMALES, RURT is found to be significantly more (P<0.05) in the thumb, index and middle fingers of the HbAA than in HbSS subjects, whereas LURD was significantly more (P<0.05) in the middle and little fingers of the HbSS. However, RRRD was significantly more (P<0.05) in the index fingers of HbSS but significantly more (P<0.05) in the ring fingers of the HbAA (Table 4).

DISCUSSION

Generally, the ulna loop pattern was the most prevalent in all the fingers of both sickle cell and control groups in both male and female subjects and in both left and right hands, except thumb which was mostly predominated by whorl. Overall, the order pattern in each finger (except thumb) was ulnar loop>whorl>arch>radial loop, and for the thumb was: whorl>ulnar loop>arch>radial loop. This result is quite similar to the findings obtained by Oladipo et al.[18] and Ramesh et al.[19], when both studied sickle cell dermatoglyphics in Lagos, Nigeria and Chhattisgarh, India respectively. However, sex and digit specific observations showed that some digits exhibited a variant of this order of ulnar loop>whorl>arch>radial loop and sometimes some pattern type is absent in some digits of the sickle cell subjects. For example, there was no radial loop in the left middle and left ring fingers of the male sickle cell subjects, which was also similar to what was obtained by Ramesh et al.[19] There was also no radial loop in the left middle and no arch in left ring fingers of the female sickle cell subjects. This is an interesting exclusion and or identification biomarkers for normal individuals (HbAA), in that, this may quite be used to identify normal individuals by ordinary checking the prints of their middle and ring fingers. For example, if left radial loop is seen in either middle or ring finger of a male, it may then serve as a pointer of excluding sickle cell genotype in that subject. Similarly, presence of an arch in the left ring finger or presence of radial loop in the left middle finger of a female indicates individual with normal genotype (HbAA). This reveals the importance of sex and digits in using fingerprint pattern as diagnostic tool of sickle cell disease especially where there is 'no lab' to carry out common genotype test. From the findings of this study, we strongly argue that frequency of fingerprint pattern alone is not so robust to be used as a screening tool except when sex and digit

specific fingerprint pattern model is developed. For example, in male sickle cell patient whorl was greater than ulnar loop in left index finger, right ring finger (arch=radial loop), right thumb and left thumb.

The present study clearly showed that people living sickle cell anemia have considerably and significantly higher RD than the control group in both ulnar and radial sides, specifically at the left index, both middle, ring or at the right little fingers. The increase in the number of ridges can be related to increased frequency of whorls in the sickle cell sample than the control group. This is similar to what was reported in the previous study where sickle cell patients had higher percentage of whorls than the control group[19]. Using different methodological approach, higher RD was also reported in the sickle cell group compared to healthy control in Indian population[20].

The control group in the present study had significantly higher ridge thickness than the sickle cell group in the left index, both middle, ring and right little fingers. This agrees with previous study[21] and may be attributed to the fact that RD has reciprocal relationship with MRT. This also project the possible use of partial or unintentionally deposited fingerprint in prediction of diseases condition. Hence, this is useful as a screening tool as well as in forensic context where any form of identity narrows the pool of suspects during the investigation.

The increase in the ridge density and decrease in ridge thickness are a typical projection of finer ridges and less body build[22,23]. This is well known phenomenon in females in which they were reported in several populations to have finer ridges and less body build compared to the males[24,25,26] including Hausa ethnic group[16].This suggestion may also be extended as plausible explanation of increase in RD in people living with sickle cell anaemia. This is because children with sickle cell anaemia are reported to progress slowly through puberty compared to health individuals, hence this resulted in decrease in growth rate[27].This manifest as overall less body build in adulthood compared to health population, hence finer ridges and increase in RD. However, it worth nothing that the ulna and radial area of digit respond differently with respect to developmental instruction[28].This may also give them different capacity as screening tool.

CONCLUSION

The present study can conclude that specific differences in fingerprint features exist between people living with sickle cell anaemia and the normal individuals. The fingerprint pattern was found to be sex and digit associated feature that can be used in the differentiation between sickle cell patients and normal individuals. There was increase in ridge density and finer ridges in sickle cell patients compared to normal individuals. Hence, the potential role of fingerprints features as a screening tool for sickle cell patients was demonstrated in this study.

Declaration of Conflict of Interest

The authors declare no conflict of interest

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