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Palmar and digital dermatoglyphic traits of sub-Saharan African subjects

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Abstract
Introduction: Dermatoglyphic traits in conjunction with other morphological, molecular and biochemical markers are extremely important in biological anthropology to explore affinities and differences between human population groups. Towards this end, not much work has been documented for sub-Saharan African subjects.
Materials and methods: Bilateral finger and palmar prints were obtained by the standard technique of Cummins and Midlo on samples of Nigerians of different tribes namely Ibos, Yorubas, Hausas and Urhobos, Kenyans and Tanzanians, Malawians and Zimbabweans, who are apparently physically healthy subjects and whose parents and grandparents were from the countries indicated above. The palmar prints obtained were classified into arches, loops and whorls. Ridge count, atd angles and pattern intensity indices were calculated according to standard methods.
Results: Ulnar loops were the most predominant palmar digital ridge patterns observed in all the studied subjects. However, the percentage frequencies of these loops vary between the regions with the East Africans having a higher percentage than Nigerians. Among South Africans, Zimbabweans had higher percentage of ulnar loops than Malawians especially the female subjects. Furthermore, the Southern Africans had the highest percentages of arches when compared with West and East Africans. The mean TFRC was highest in Southern Africans, high in East Africans but least in Nigerians while the mean atd angle and a-b ridge counts were highest in East Africans high in Southern Africans and again least in Nigerians except for Malawian females. PII values were, however, highest in Nigerians than East and Southern Africans whose values were less than 10.
Conclusion: This study has demonstrated significant regional dermatoglyphic variability between Nigerians, East and Southern Africans in atd angles a-b ridge counts, TFRC and PII an indication of the usefulness of dermatoglyphic traits in the study of population dynamics. However, inspite of these differences, sub-Saharan African populations fit within the well-established clinal distribution of traits, showing a comparatively high whorl frequency among northernly located population groups.

Keywords: *Palmar, digital, dermatoglyphics, sub – Saharan, African subjects.*

Résumé
Introduction : Les traits dermatoglyphes en conjonction avec d'autres marqueurs morphologiques, moléculaires et biochimiques, sont extrêmement importants en anthropologie biologique pour explorer les affinités et les différences entre les groupes de population humaine. À cette fin, peu de travaux ont été documentés sur des sujets d'Afrique subsaharienne.
Matériels et méthodes : Des empreintes digitales et palmaires bilatérales ont été obtenues selon la technique standard de Cummins et Midlo sur des échantillons de différentes tribus Nigérianes notamment Ibos, Yorubas, Haoussas et Urhobos, Kenyans et Tanzaniens, Malawiens et Zimbabwéens, sujets apparemment en bonne santé physique dont les parents et grands-parents étaient originaires des pays indiqués ci-dessus. Les empreintes ulnaires obtenues ont été classées en arches, boucles et tours. Le dénombrement de la crête, les angles atd et les indices d'intensité de motif ont été calculés selon les méthodes standard.
Résultats : Les boucles ulnaires étaient les motifs numériques de crêtes palmaires observés les plus prédominants chez tous les sujets étudiés. Cependant, les fréquences en pourcentage de ces boucles varient d'une région à l'autre, les pourcentages étant plus élevés chez les Africains de l'Est que chez les Nigérians. Parmi les Africains du Sud, les Zimbabwéens présentaient un pourcentage plus élevé de boucles ulnaires que les Malawiens, en particulier les sujets féminins. En outre, les pourcentages d'arcades étaient les plus élevés parmi les Africains du Sud, par rapport aux Africains de l'Ouest et de l'Est. La TFRC moyenne était plus élevée parmi les Africains du Sud, élevée parmi les Africains de l'Est, mais moins chez les Nigérians, tandis que les dénombrements moyens entre angles

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for as far back as they know, and anyone who gave a positive answer was excluded. In the case of related individuals in the sample, only the print of one of them was included in the analysis as is conceivable that statistics indicating the occurrences of particular features might be distorted by the introduction of several members of a family in a relatively small collection [28].

Malawians and Zimbabweans

The sample consisted of 231 Malawians (142 females and 89 males) aged between 11-39 years form Chichiri Secondary School and from members of staff of the College of Medicine all in Blantyre. The Zimbabweans sample consisted of 135 males and 135 females aged between 11-47 years from Mufakose high density township in the cosmopolitan cities of Harare and Gweru cities in Zimbabwe's midlands. This gave a good mixture of social backgrounds to allow for the inclusion of quantitative palmar variables [29]. The subjects were apparently physically healthy with Malawian and Zimbabwean parents and grandparents, respectively. The subjects were also asked individually if there were any non-Malawian or Zimbabwean ancestry for as far back as they know, and anyone who gave a positive answer was excluded.

Table 1a: The Percentage frequency of digital patterns of Yorubas and Ibos of Nigeria.

Pattern Types	Yorubas						Ibos					
	Male			Female			Male			Female		
	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean
Arch	10.20	10.10	10.10	11.60	10.20	10.90	14.40	11.40	12.90	12.90	11.40	12.40
Radial Loop	10.90	2.70	2.30	2.30	1.10	1.70	2.30	2.60	2.50	3.10	2.10	2.60
Ulnar Loop	61.20	58.70	60.00	60.50	62.40	62.00	62.00	61.80	61.90	55.70	58.30	57.00
Whorl	26.70	28.50	25.70	23.30	23.30	24.50	22.30	24.20	22.30	28.30	28.10	28.20

Kenyans and Tanzanians

The sample consisted of 304 Kenyans (164 males, 140 females) aged 12-14 years from Nairobi Primary School and 300 Tanzanians (180 males, 120 females) aged 19-24 years who are students of Muhimbili University College of Health Sciences. The subjects were apparently healthy volunteers whose parents and grandparents were either Kenyans or Tanzanians respectively.

They were selected from the cosmopolitan cities of Nairobi and Dar-es-salaam respectively, giving a good mixture of social backgrounds to allow for the inclusion of quantitative palmar variables [29]. Furthermore, the subjects were asked individually if there were any non-Kenyan or Tanzanian contribution to their ancestry for as far back as they knew, and anyone who gave a positive answer was excluded. In the case of related individuals in the sample, only the print of one of them was included in the analysis as is conceivable that statistics indicating the occurrences of particular features might be distorted by the introduction of several members of a family in a relatively small collection [28].

Bilateral finger and palmar prints were obtained by the standard technique of Cummins and Midlo [28]and only clear prints were classified into arches, loops and whorls (Fig 1) and ridge counts were performed according to the method described by Arrieta et al.,[30].Inter-observe variations were eliminated as one person examined all the prints. The following features were examined;

Table 1b: The total finger ride count (TFRC) and pattern intensity indices of Yoruba and Ibos of Nigeria

	Yorubas		Ibos	
	Male	Female	Male	Female
TFRC Mean	101.60	121.60	113.80	111.40
SD	37.90	39.20	44.30	40.20
*PII Mean	11.74	11.36	11.03	11.60

**PII was calculated from pattern intensity type frequency totals; hence standard deviations were not obtained .n.s= not significant.*

The total finger ridge counts (TFRC) are the sum of the ridge-counts (largest count only when there is more than one) on all ten fingers for each gender.

Pattern intensity index (PII) was the mean number of triradii on digits per individual subject. This reflects the complexity of the finger patterns in an

et arêtes étaient plus élevés chez les Africains de l'Est et élevés parmi les Africains du Sud, mais encore moins chez les Nigérians, à l'exception des Malawiennes. Les valeurs PII étaient toutefois plus élevées chez les Nigérians que chez les Africains de l'Est et du Sud dont les valeurs étaient inférieures à 10.

Conclusion : Cette étude a démontré une importante variabilité des dermatoglyphes régionales entre les Nigérians, les Africains de l'Est et du Sud - dans le nombre des angles atd de crêtes ab, TFRC et PII une indication de l'utilité des traits dermatoglyphes dans l'étude de la dynamique des populations. Cependant, malgré ces différences, les populations d'Afrique subsaharienne s'inscrivent dans la distribution clinal bien établie des traits, la distribution, montrant une fréquence de spores relativement élevée parmi les groupes de population situés au nord.

Mots - clés : *Palmaire, numérique, dermatoglyphes, subsaharienne, sujets africains.*

Introduction

The principle of dermatoglyphics focuses on the ridges formed in the raised apertures of sweat glands that have unique detailed formations, are much less fortuitous in origin and anatomical regularities [1]. Dermatoglyphic traits, along with other morphological, molecular and biochemical markers have traditionally been used in biological anthropology to explore affinities and differences among human groups [2]. There are also normal variation in these traits, which represent hereditary differences between members of separate populations and members of the same population or family. Thus, dermatoglyphic traits are most useful in studying population dynamics [3].

The use of dermatoglyphic traits as racial indicators has demonstrated that human races did not differ in the expressions of any of these traits, but they differed only in the relative frequencies of the traits [4]. This initial view was, however, later altered slightly when Jantz and Parham [5] showed that ridge breadth was found to differ among populations. However, a few instances have shown that dermatoglyphic traits could substantiate racial history interpretations as shown in the confirmation of blood group evidence[6] and separate lines of population history for African and Asian (Oceanic) pygmy populations [7]. The value of dermatoglyphic traits in tracing population history was further enhanced by Birdsell [8] when he postulated that complex genetic traits (those under polygenic control) are more useful than simple genetic traits in terracing widely separated or distantly related populations. Rife [9] and Newman[10]confirmed the above assertion when they concluded that the polygenic nature of dermatoglyphic traits make them less subject to random genetic drift, and in addition they are free of assortative mating effect hence less subject to environmental influences and gene flow. This makes dermatoglyphic traits most suitable for "classifying older and more basic relationships between populations".

Studies on Caucasians [11-13] have demonstrated that dermatoglyphic traits could he used in tracing the history and relationships of population. In this connection, Wilder [14] showed that racial differences existed in the palm and finger configuration of Germans. European—Americans, Chinese and Japanese. The distribution of fingerprint characteristics in Whites and Negroes living in Brazil have also been documented and the most marked difference observed between Whites and the total Negroid group was in the prevalence of radial loops [15].

Studies in sub-Saharan Africans have shown total finger ridge count (TFRC) variability among various African population groups [16-19]. Ogunye and Sagay [20], for example, showed that sexual dimorphism was exhibited by the atd angle of the Zulus of South Africa, who also demonstrated a lower 'TFRC' when compared with Southern Nigerians. On the other hand, Borofﬁce [21], Jantz and Brehme [22] and Igbigbi *et al* [23] studied the digital and palmar dermatoglyphics of the Yoruba and Ibo tribes of Nigeria, showing dermatoglyphic differences between both tribes. . In the same vein, Igbigbi and Msamati [24,25] have reported on the digital and palmar dermatoglyphics same parameters in Malawian and Zimbabwean subjects. Other studies on Southern African populations have documented the dermatoglyphics of South African Negro [26] and the Pandamatenga Bush-Bantu hybrid of Botswana [27]. These studies have clearly demonstrated that dermatoglyphic traits differ among the various African groups, hence can be used to differentiate them.

Despite the importance of dermatoglyphic traits enumerated above, not much work has been documented for African subjects especially those in sub-Saharan African region. This study aimed at filling this gap in knowledge and also in presenting the palmar and digital dermatoglyphic trait profiles of sub-Saharan Africans using subjects from West, East and Southern Africa.

Materials and methods

Nigerians

The sample consisted of 390 Ibo (250 males, 140 females), 383 Yoruba (250 males, 133females), 625 Hausa (320 males, 305 females) and 612 Urhobo (342 males, 270 females). The subjects were apparently healthy volunteers aged 13-25 years whose parents and grandparents were of the Nigerian tribes indicated above. Furthermore, the subjects were asked individually if there was any non-member of the tribes above that contributed to their ancestry

Table 2b: The total finger ride count (TFRC) and pattern intensity indices of Hausas and Urhobos of Nigeria

	Hausas			Urhobos		
	Males	Females		Males	Females	P
TFRC	130.11	127.74	P<0.05	115.46	110.48	P<0.05
SD	9.13	8.20		16.83	15.47	
*PII Mean	12.64	11.59		11.20	11.40	

Table 2c: The atd angle and a-b ridge counts of Hausas and Urhobos of Nigeria

	Hausas			Urhobos		
	Males	Females		Males	Females	P
atd angles Mean	78.04	79.72	n.s	59.90	76.60	P<0.05
SD	7.91	6.26		8.70	7.80	
a-b ridge count Mean	72.95	78.66		74.40	73.40	n.s
SD	10.38	9.35	P<0.05	8.94	8.90	

n.s = not significant

Table 2d: Comparison of dermatoglyphic variables between Hausas and Urhobos of Nigeria

	Hausas	Urhobos		
	Males	Females	Males	Females
TFRC Mean	130.11	124.74	113.60	11.40
SD	9.13	8.20	44.30	40.20
N	320	305	342	270
atd angles Mean	78.04	79.72	59.90	68.10
SD	7.91	6.62	8.70	15.47
a-b ridge counts Mean	72.95	78.66	74.40	74.40
SD	10.38	9.35	6.10	8.94
P II Mean	12.64	11.59	11.20	11.40

Table 3a: The Percentage frequency of digital patterns of Kenyan and Tanzanian subjects

Pattern Types	Kenyans						Tanzanians					
	Males			Females			Males			Females		
	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean
Arch	5.71	4.28	4.99	3.16	2.63	2.89	5.11	4.67	4.89	3.33	3.33	3.33
Radial Loop	6.25	6.42	6.34	6.32	6.32	6.71	6.67	7.04	6.86	7.50	7.50	7.50
Ulnar Loop	69.05	76.19	172.62	69.12	70.18	69.65	65.66	68.89	69.22	79.17	70.83	75.00
Whorl	18.99	13.11	16.05	21.40	20.08	20.75	22.66	19.40	21.03	10.00	18.34	14.44

a significant difference in the rather unusual direction of males having fewer whorls and more arches than females (P<O.01). In terms of ethnic group comparisons, the gender of both groups were found to be significantly different from each other (P<0.0l). There was, however, a striking contrast between the Yoruba and Ibo females who had more whorls and fewer arches than their counterpart. For both groups, the most predominant digital ridge pattern was the ulnar loop.

Tables lb and 1c show quantitative dermatoglyphic variables of TFRC, PII, atd angles

Table 1c: The atd angle and a-b ridge counts of Yorubas and Ibos of Nigeria

	Yorubas			Ibos		
	Male	Female		Male	Female	P
atd angles Mean	76.30	77.90	n.s	77.10	76.60	
SD	4.70	11.80		4.10	7.80	
Mean a-b ridge	72.80	74.40	P<0.05	74.20	73.40	n.s
SD	8.50	5.90		8.50	8.90	

n.s = not significant

Table 1d: Comparison of dermatoglyphic variables between Yorubas and Ibos of Nigeria

	Yorubas		bos	
	Male	Female	Male	Female
TFRC Mean	101.60	121.60	113.60	11.40
SD	37.90	39.20	44.30	40.20
N	250	133	250	140
Atd angles Mean	76.30	77.90	77.10	76.60
SD	4.70	11.80	4.10	7.80
a-b ridge count Mean	72.80	74.40	74.20	73.40
SD	8.50	5.90	8.50	8.90
PII Mean	11.74	11.36	11.03	11.60

individual or population. In this system, arches having no triradii are scored 0; loops representing pattern formation with one triradii are scored 1; and whorls or composite patterns with two (or more) triradii are scored 2. The pattern frequency of a population is therefore summarized by the finger pattern intensity index representing the mean number of digital triradii per person.

The *a-b ridge* count represents the number of ridges observed between triradii a and b.atd angle: This was the angle between two straight lines joining the radial (a) and ulnar (d) triradii to the hypothenar triradius (Fig 1).

The results of the ridge patterns, TFRC, PII, atd angle and a-b ridge counts were analyzed statistically using the X^2 test with 2 degrees of freedom for pattern type intensity, and t tests for matched or unmatched pairs as appropriate for TFRC, atd angles and a-b bridge counts. The data were then compared between all the studied subjects in the respective countries.

Table 2a: The Percentage frequency of digital patterns of Hausas and Urhobos of Nigeria.

Pattern Types	Hausas						Urhobos					
	Male			Females			Males			Females		
	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean
Arch	9.49	7.05	8.27	16.07	13.71	14.89	14.56	11.80	13.18	14.10	11.80	12.9
Radial Loop	1.28	2.38	1.83	2.10	1.72	1.91	2.74	3.70	3.22	2.00	1.90	1.95
Ulnar Loop	54.93	53.79	54.36	51.87	53.07	52.47	53.00	49.40	52.20	51.30	54.70	53.0
Whorl	34.30	36.78	35.54	29.96	31.50	30.73	29.70	35.11	32.40	32.60	31.60	32.1

Results

Palmar ridge patterns

Palmar ridge patterns did not exhibit gender dimorphism in all our sampled subjects. This notwithstanding, differences were shown in the various ridge patterns within and between the groups but again these differences were not statistically significant (P>0.05)

Digital ridge patterns

Table la shows the digital pattern type distributions for both gender in the Ibo and Yoruba subjects. With regards to gender dimorphism, only the Ibos showed

Digital patterns

Table4b: The total finger ride count (TFRC) and pattern intensity indices of Malawian and Zimbabwean subjects

	Malawians			Zimbabweans		
	Males	Females		Males	Females	P
TFRC Mean	123.72	140.15		126.65	123.71	
SD	39.82	39.82	<0.001	27.38	27.51	0.5
*PII Mean	7.65	6.66		10.83	10.18	

Table 4c: The atd angle and a-b ridge counts of Malawian and Zimbabwean subjects

	Malawians			Zimbabweans		
	Males	Females		Males	Females	P
atd angle Mean	72.06	80.66		72.70	82.40	P<0.01
SD	8.30	8.50	P <0.001	5.98	10.08	
a-b ridge count Mean	79.74	64.66		79.34	79.40	<0.5
SD	16.88	13.22	<0.001	9.58	8.18	

n.s = not significant

Ulnar loops were the most prevalent finger ridge patterns and arches were the least type in the sampled populations. Significant gender differences were exhibited in arches, ulnar loops and whorls in the sampled populations (P<0.05, Table 1a).

Table 2a shows that Hausa females had more arches than their male counterpart but slightly less ulnar loops and whorls. The Urhobo females on the other hand had slightly more ulnar loops but slightly less arches, radial loops and whorls when compared with their male counterpart. Significant gender differences where observed in TFRC in Hausa and Urhobo subjects (P<0.05; Table 2b). Hausas showed little or no difference in mean atd angle between the gender (P>0.05). While there was a significant difference in the mean atd angle for Urhobo females and males (P<0.05; Table 2c). The mean a-b ridge count was, however, significantly higher in Hausa females than in males (P<0.05; Table 2d). Like the Ibo and Yoruba subjects, the Urhobo and Hausa subjects showed that ulnar loops were the most predominant ridge pattern.

Ulnar loops were the most prevalent finger ridge patterns and arches were the least type in Kenyan and Tanzanian subjects. Significant gender differences were exhibited in arches, ulnar loops and whorls in both groups (Table 3a).

Table 3b shows the mean total finger ridge count (TFRC), mean atd angles, mean ab ridge counts and pattern intensity index (PII) by gender. There

Table 4d: Comparison of dermatoglyphic variables between Malawian and Zimbabwean subjects

Variables	Malawians		Zimbabweans	
|	Males	Females	Males	Females
TFRC Mean	123.72	140.15	126.65	123.71
SD	39.82	39.82	27.38	27.51
N	89	142	135	135
atd angle Mean	72.74	80.66	79.70	82.40
SD	8.30	8.50	5.98	10.08
a-b ridge count Mean	79.74	64.66	79.34	79.40
SD	16.88	13.22	9.58	8.18
P II				
Mean	7.65	6.66	10.83	10.18

Table 3b: The total finger ride count (TFRC) and pattern intensity indices of Kenyan and Tanzanian subjects

	Kenyans Males	Females		Tanzanians Males	Females	P
TFRC Mean	125.60	116.26		115.05	114.9	
SD	39.0	32.16	<0.01	32.14	32.50	n.s >0.5
*PII Mean	7.94	8.91		8.23	7.29	

Table 3c: The atd angle and a-b ridge counts of Kenyan and Tanzanian subjects

	Kenyan Males	Females		Tanzanian Males	Females	P
atd angle Mean	85.20	86.78	<0.	72.981	78.00	<0.05
SD	10.24	11.50		8.80	7.22	
Mean	89.60	87.00	0.001	83.42	83.42	<0.01
SD	15.36	17.34		19.80	18.90	

n.s = not significant

and a-b ridge counts. For TFRC, significances were observed within and between the Ibo and Yoruba subjects (P<0.01). The mean TFRC in Yoruba female was significantly higher than the mean for Yoruba males while the reverse was the case for the Ibo. Similarly the mean a-b ridge count of Yoruba females was significantly higher than that of their males counterpart (P< 0.05). The mean PII showed remarkably little variation between the gender and across the two groups. However, the other variables of atd angles and a-b ridge counts showed little inter-gender and inter group variations (Table 1d).

Table 3d: Comparison of dermatoglyphic variables between Kenyan and Tanzanian subjects

	Kenyan Male	Female	Tanzanian Male	Female
TFRC Mean	125.60	116.26	115.05	114.90
SD	39.0	32.16	32.14	32.50
N	164	140	180	120
Atd angle Mean	85.20	86.78	77.98	78.00
SD	10.24	11.50	8.86	7.22
a-b ridge count Mean	89.60	87.00	85.42	83.42
SD	15.34	17.34	19.80	18.90
P II Mean	7.94	8.91	8.23	7.09

Table 4a: The percentage frequency of digital patterns Malawian and Zimbabwean subjects

Pattern types	Malawians						Zimbabweans					
	Males			Females			Males			Females		
	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean
Arch	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Radial Loop	8.67	6.67	7.67	5.00	5.45	5.21	5.55	5.55	5.55	6.67	6.67	6.67
Ulnar Loop	73.33	46.67	60.00	41.67	37.50	39.59	77.77	66.66	72.22	78.88	77.77	78.33
Whorl	8.00	36.66	22.33	43.33	47..08	45.20	66.86	17.79	4.45	10.00	4.56	5.00

higher than those of East Africans (Kenyans and Tanzanians) and was followed by Nigerians representing West Africa. Similarly significant differences were also recorded in a-b ridge counts between Nigerians and East Africans (P<0.01). However, the mean atd angle was significantly highest in East Africans, followed by South Africans and then Nigerians (P<0.01). In the same vein, the mean a-b ridge count was highest in East Africans, followed by South Africans and then Nigerians except Malawian female subjects. However, PII was highest in Nigerians, followed by Zimbabweans, then East Africans, while Malawians were the least.

Discussion

Palmar ridge patterns

This study has demonstrated that palmar ridge patterns do not show gender dimorphism and therefore are not useful in gender differentiation in a given population. Previous studies in African subjects [16,21,26,32], Caucasians [30-32], Chorote Indians [34] Japanese and Chinese [14] support the above finding. Wilder [14] had also shown that there was a greater frequency of occurrence of the hypothenar patterns in the 'White' over that seen in the 'yellow' races hut no gender differences in the pattern peculiarities were shown. Despite this lack of gender dimorphism palmar ridge patterns tend to show close relationship between members of the same group. This was demonstrated in this study as exemplified by the similarities of palmar ridge patterns amongst Nigerians. Kenyans and Tanzanians, and then Malawians and Zimbabweans. Similarly, individuals from the same countries tended to have similar palmar ridge patterns than their close neighbours.

The present study has also shown the prevalence of digital ulnar loops followed by whorls as, indeed, was the case with other African populations earlier studied[17,26,27,35]. However, Kenyan men had more ulnar loops than women, as was the case with the Zulus of South Africa [26]. This is an interesting finding for a number of reasons. It emphasized that prints of the finger palmar surface provide a distinct technical record in physical anthropology [36] because they have greater phylogenetic stability [37]. However, in Caucasians, high frequencies of digital arches and radial loops in both gender have been reported [30]. These findings underline the usefulness of digital patterns in differentiating population groups. In this connection, De sa Benevides and Salzano [15] had also shown that the most marked difference between whites and the total Negroid group was the prevalence of radial loops in the latter than the former. In another study on the Hehe tribe of Tanzania it was shown that the finger pattern types of women showed rather greater than usual elevation in the total frequency of loops and a diminution in whorls [32], which was also shown in this study. As far as we know the only other female sample with high loop frequency was in Mozambique [32]. The present study has also demonstrated a higher frequency of loops in both gender of both groups, suggesting dermatoglyphic similarity between Kenyans and Tanzanians.

In this light, therefore, Nigerians of West Africa could be differentiated from the East Africans and also from Southern Africans. Although these differences, which existed in the palmar surfaces, were statistically not significant, they may provide a bird's eye view of the differences between population groups.

Digital ridge patterns

The study has further demonstrated that population groups can be differentiated using digital ridge patterns. Among Nigerians, the predominant digital ridge pattern was ulnar loops followed by whorls. In Malawians and Zimbabweans, ulnar loops were the most predominant pattern type on both gender followed by whorls in males and arches in females while in Kenyans and Tanzanians it was also loop with arches the least. For Caucasians, however, high frequencies of arches and radial loops in both gender have been reported [30]. Holt [2] showed that certain patterns tend to occur more frequently on some digits than on others and these seem to be constant for any population group. Holt's observation supported the findings of this study. It appeared that digital ridge patterns were more specific than palmar ridge patterns and they also exhibited gender dimorphism. The distribution of characteristic digital ridge patterns also differentiated members of the same country, as indeed was the case with tribal groups in Nigeria.

Within the East African countries of Kenya and Tanzania, the most predominant digital ridge pattern variation between them could be used to differentiate them. This was also the case with Malawians and Zimbabweans.

Furthermore, as previous study on the Hehe tribe of Tanzania had shown that among women, there were a usual elevation in the total frequency of loops and a diminution in whorls. Boroffice [21] had also shown this phenomenon that among sub-Saharan Africans; there was a well-established clinal was significant gender difference in TFRC in Kenyans (P<0.01) but none in Tanzanian subjects

Tables 5: Comparism of dermatoglyphic variables of Nigerian, Kenyan, Tanzanian, Malawian and Zimbabwean Subjects

Varibles	Nigerians		Kenyans		Tanzanians		Malawins		Zimbabweans	
TFRC Mean	115.24	117.80	125.60	116.26	115.05	114.90	123.72	140.15	126.65	123.71
SD	27.04	25.77	39.00	32.16	32.14	32.50	39.82	39.82	27.38	27.51
N	1162	848	164	140	180	120	89	142	135	135
atd angle mean	72.84	77.71	85.20	86.78	77.98	78.00	72.06	80.66	72.70	82.40
SD	6.35	8.50	10.24	11.50	8.86	7.22	8.30	8.50	5.98	10.08
a-b ridge count	73.59	74.97	89.60	87.00	85.42	83.42	79.74	64.66	79.34	79.40
mean	9.08	8.26	15.34	17.34	19.80	18.90	16.88	13.22	9.58	8.18
SD										
PII Mean	11.65	11.49	7.94	8.91	8.23	7.09	7.65	6.66	10.83	10.18

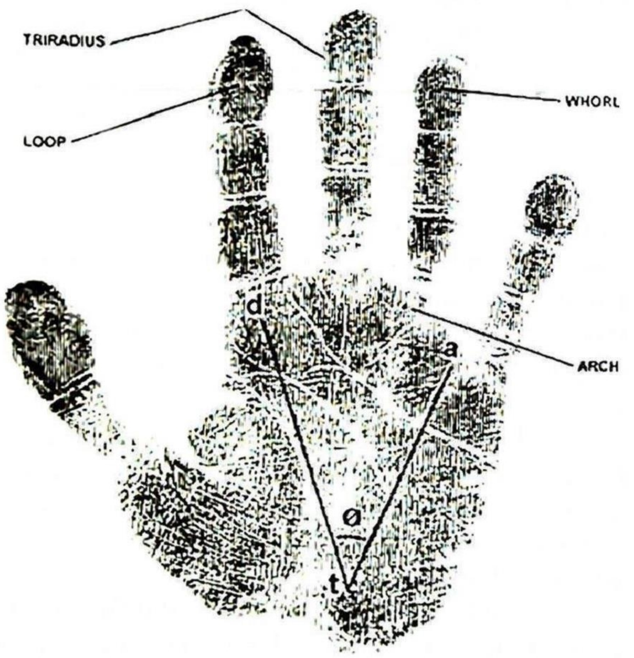

Fig. 1: Palmar and digital print showing arches, loops, whorls, triradius and atd angles

(P<0.05). In both groups men showed significantly higher mean a-b ridge counts than women (P<0001, Kenyans; P<0.01, Tanzanians). Women had higher mean atd angles than men in both groups but the difference were not statistically significant (P>0.5) table 3c). Women had also higher PII than Kenyan men and the reverse was the case in Tanzanians.

Similar significant differences also existed in all the above parameters between Malawians and both Kenyans and Tanzanians (P<0.001). However, the level of significance between Malawian and Tanzanian men in TFRC, and between Tanzanian men and women in atd angle differed (P<0.01). The TFRC in females was higher in Malawians, high in Kenyans and least in Tanzanians; for men it was higher in Kenyans, high in Malawians and least in Tanzanians. A similar trend emerged with the a-b ridge counts. The PII of Kenyans was closer to the indices of Tanzanians than those of Malawians (Table 3d).

The overall distribution of the palmar patterns was not significantly different between hands or between gender in Zimbabwean subjects (P>0.05). Ulnar loops were the most predominant pattern type in both gender, followed by whorls in males and arches in females; however, the gender differences between these digital pattern types were not statistically significant (P >0.05, Table 4a).

Table 4b shows the total finger ridge count (TFRC), atd angle, a-b ridge count and pattern intensity index (PII) by gender. Females had significantly wider atd angles than males (P <0.01); males, however, had slightly higher PII values than females, but the difference was not statistically significant (Chi P >0.5). There were no significant differences between the gender in TFRC and a-b ridge counts (P> 0.5) (Table 4c)

Similarly significant difference also existed between Zimbabwean and Malawian females and between Zimbabwean and Nigerian men in TFRC and a-b ridge counts (P <0.001). Significances were also found between Zimbabwean and Malawian males; male Zimbabweans and Nigerians. Male Zulus and Yorubas also showed significant differences in atd angles (P <0.001).

Table 5 shows the comparison of the dermatoglyphic variables of Nigerian, Kenyan, Tanzanian, Malawian and Zimbabwean subjects. The mean TFRC of South Africans represented by Malawian and Zimbabwean subjects was significantly

The a-b ridge count of a person is the total of the a-b counts of the two hands. This ranges from below 70 to over 100. Counts of 78 or below are classified as "low", those of over 78 are "high"[44]. The genetic factors, which determined variation in the a-b ridge counts, had been analyzed and consisted of a main gene, whose expression was affected by multiple modifying factors. The allele that determines a high count (79) ridges and over was dominant over the allele determining a low count. Modifying factors affect the place in the high or low category the individual occupied [44]. The study showed Nigerians had least counts, followed by East Africans and high for Southern Africans. There was an increase in the counts from West to East with Malawians having the lowest counts probably reported for Africans for the first time. However, all subjects had low ridge counts based on pons classification. Pons [45] showed that racial differences existed in the human palm with regards to a-b ridge counts. He showed that the a-b ridge counts for white populations vary between 80 and 86 ridges, black populations between 74 and 80, Indian subcontinent 68 and 80, while American Indians have between 80 and 90. This study has also shown that a-b ridge count can be used to differentiate the different population groups in sub-Saharan subjects. The higher values reported by Pons are applicable to West Africans as values in Nigerians have shown.

Furthermore, this study has demonstrated that using all dermatoglyphic variables, significant differences existed with Nigerians having the least, Southern Africans being high and the East Africans showed the highest mean atd angles and a-b ridge counts. Similarly Nigerians also had the least TFRC, high for East Africans and higher for Southern Africans (P <0.01). The mean PII was also highest for Nigerians; these regional findings could be explained on linguistic grouping disparities advanced by Jantz and his colleagues [17] when they showed that linguistically all black Africans were represented in two groups namely, Niger-Congo and Benue-Congo. Another explanation may be the linguistic grouping proximity and by extension common ancestry [17]. The dermatoglyphic distance and the admixture of other language groups like Arabic, Chinese and Portuguese as was the ease with Kenyans and Tanzanians may indeed explain some of these dermatoglyphic differences between countries from the same linguistic grouping of Jantz [17].

Conclusion

This study has, however, shown the usefulness of dermatoglyphic traits in the study of population dynamics, which was demonstrated by Chai [46]. However, in spite of the differences, sub-Saharan African populations fit within the well-established clinal distribution, showing a comparatively high whorl frequency among northernly located population groups. But for the first time these West-to-East increasing trends is described within palmar and digital ridge patterns.

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distribution of a comparatively high whorl frequency among northernly located population groups.

The mean TFRC was significantly higher in females than males (P<0.001) in Malawians[24] contrary to the findings of Arrieta et al.,[30] in Caucasians where males had higher mean TFRC than females, even though the differences were not statistically significant between the limbs. This finding suggests racial differences between Malawian and Caucasian samples. The mean TFRC did not show gender dimorphism in Zimbabweans and was significantly higher in males than females [25]. A report on Nigerian subjects also showed gender dimorphism in mean TFRC [23]. Among Kenyans the mean TFRC showed gender dimorphism while in Tanzanians none was exhibited. However, in East Africans the mean TFRC was higher in men than women [38]. These findings suggest that mean TFRC can differentiate population groups among sub-Saharan Africans. A Comparison of the dermatoglyphic traits of Kenyans, Tanzanians and of Malawians previously reported[24], revealed significant differences between Kenyans and Tanzanians with respect to TFRC, atd angle and a-b ridge counts (P<0.001). Indeed it had been shown that racial differences do exist between Africans and Caucasians in mean TFRC [30]. Blecher [27] also showed that mean TFRC was lower in African groups than in British samples with the difference most marked in males. Basu and Namboodiri [39] also demonstrated that males generally had higher values of mean TFRC than females. They also showed the importance of TFRC as a strong inherited variable and a useful parameter to describe, compare and contrast various populations. The importance of TFRC shown in this study between Malawians and Zimbabweans and Kenyans and Tanzanians supports the observation of Holt [40]. The mean TFRC was least in Nigerians of West Africa, higher in subjects of Southern Africa and high in East Africans.

The study has demonstrated gender dimorphism in TFRC in Kenyans but none in Tanzanians. However, in both groups the mean TFRC was higher in men than women. This is the opposite of what was reported in Malawians [24] but it was in agreement with what was reported among valley Basques when compared with other Spaniards [30]. Previous study had indeed shown that racial differences do exist between Africans and Caucasians in mean TFRC [30]. Other authors have also demonstrated that the mean TFRC was lower in African than in British samples but the difference was most marked in men [27]. Our findings tend to suggest that mean TFRC can also differentiate African population groups as was demonstrated in the comparison of the dermatoglyphic traits of the Zulus of South Africa from a previously documented study with the Yorubas of Western Nigeria, which showed significant differences in TFRC and a-b ridge counts (P<0.001). Difference in total finger ridge count frequencies between different populations may also be expected, since the frequencies of arches, loops and whorls vary between races [27].

The mean PII was higher in Nigerians, high in Zimbabweans and East Africans and it was least in Malawians. Similarly the mean PII in both gender was higher among Zimbabwean subjects than Malawians, and in both gender are comparable with those of Pandamatenga hybrids of Botswana [27]. The mean PII was higher in Kenyan women than men but the reverse was the case in Tanzanian and Malawian subjects. There was no clear-cut male/female divide in mean PII in Nigerians and there may be a closer dermatoglyphic link between Malawians and Tanzanians exhibited by the mean P11. Some researchers [41-43] had shown that mean TFRC was a more qualified and specific dermatoglyphic variable than P11. This study has also demonstrated this fact. PII could not differentiate the studied populations into west, east, and southern dermatoglyphic groups hut the mean TFRC had done so.

Moreover, it has been shown that the PII was higher in Kenyan women than men but the reserve was the case in Tanzanian and Malawian subjects (Tables 3b, 4b). This may indicate a closer dermatoglyphic link between Malawians and Tanzanians.

The mean atd angle was also found to be higher in women than men in this study but the differences were not statistically significant, thus confirming the reports in other populations [24,27,35]. The mean atd angle was also found to be higher in women than men in all our studied subjects. This has been reported in other human populations [24,27]. However, the mean atd angle was higher in East Africans, high in Southern Africans and least in Nigerians. In addition there was a gradual increase of atd angle form northernly located population down south, and a West-to-East increase. A previous study by Penrose [1] had highlighted the important role of atd angle in differentiating population group because of its genetic determination but its only drawback was the fact that it was influenced by age and early foetal environment.