Plantar and digital dermatoglyphic patterns in Malawian patients with diabetes, hypertension and diabetes with hypertension

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Abstract

In this study we examined the dermatoglyphic features of 99 Malawian patients with diabetes, hypertension and diabetes with hypertension, attending the outpatient clinic at Lilongwe and Queen Elizabeth Central Hospitals. Plantar and digital pattern types were determined and their variability was calculated using Dankmeijer's (DI) and pattern intensity (PII) indices. The results showed that the soles of all patients had more loops than arches and more arches than whorls, which were restricted to the distal zones. In hypertension, whorls were found in zones I, II and III whereas in patients with diabetes and hypertension, the whorls were seen in zones I, III and IV. In digits the most predominant ridge pattern were arches in all patients, followed by loops and whorls were absent. In the first digit, diabetic patients had no arches but women hypertensives showed arches. In patients with diabetes and hypertension, arches were present in both sexes but in men it was confined to the right foot. Loops were only found in the first digit in all patients. The frequency of loops was highest in diabetic patients, high in diabetics with hypertension and least in patients with hypertension alone. Using PII and DI indices, there were significant differences between patients and healthy Malawian subjects ($P < 0.001$), and between the sexes ($P < 0.01$), but PII did not show significant differences with sex ($P > 0.5$) in hypertensives. Diabetic patients had the lowest mean DI when compared to the other groups. In conclusion, this study has demonstrated plantar and digital dermatoglyphic differences between patients and healthy Malawians, differences that were exhibited more in digital than in plantar ridge patterns. The disease conditions were indicated better by whorls in topographical zones IV of the sole and by the presence and frequency of loops in the first digit.

Key words: *Plantar dermatoglyphics, diabetes and hypertension*

Introduction

The science of dermatoglyphics involves the study of epidermal ridges present on the surface of palms, fingers, soles and toes.[1,2] These epidermal ridges form well-defined patterns that characterise individuals and they have been found useful in the clinical diagnoses of hereditary diseases.[3] Epidermal ridge patterns form early in fetal development and they remain unchanged throughout life and hence they could be used to indicate gene or chromosomal abnormalities.[4]

Studies in Indians have shown links between diabetes mellitus and dermatoglyphic features.[4-9] Although the total finger ridge count (TFRC) in diabetics has been reported by various workers with contradicting results,[5-7] these authors nevertheless demonstrated that the ridge patterns are affected one

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way or the other by diabetes mellitus. However, their findings were restricted to palmar and digital ridge patterns alone. The literature on plantar dermatoglyphics for diabetics is lacking and reports on black African subjects in general are not available. Essential hypertension is another condition with genetic influence. It is defined as sustained high blood pressure not attributable to a single cause but reflecting the interaction of multiple genetic and environmental influences, such that siblings of hypertensive parent or parents stand a higher chance of developing hypertension in later life.[10] As with diabetes, no dermatoglyphic reports on black subjects are available.

Since palmar dermatoglyphic patterns have been demonstrated in diabetic patients, are there specific plantar patterns in addition? Secondly, do such patterns also exist in essential hypertensives, and in patients with both diabetes and essential hypertension? In an attempt to answer these questions we carried out this study on adult black Malawian patients.

Materials and methods

We recruited 99 indigenous Malawian patients aged 25 – 66 years attending the medical outpatient clinic for diabetes mellitus, essential hypertension and a combination of the two conditions at Lilongwe and Queen Elizabeth central hospitals. They consisted of 27 diabetics (15 males, 12 females), 21 hypertensives (9 males, 12 females) and 51 diabetics with hypertension (21 males, 30 females). All patients were diagnosed after the age of 20 years and suffered from Type 2 diabetes.

The sole was mapped topographically into 10 zones based on Cummins and Midlo's 1961-nomenclature,[11] where zones I-V represented the distal plantar sole and zones VI - X represented the proximal plantar sole. These were the zones used to describe the characteristics reported in the study (Fig. 1, Table 1).

Bilateral plantar and digital prints of the sole were obtained by the inking method of Cummins and Midlo.[11] The various plantar and digital patterns of arches, loops and whorls (Fig. 2) were counted and classified with the aid of a hand lens using Loesch and Skrinjaric's method.[12] The frequencies of the ridge patterns were expressed as percentages of the total pattern types and analysed using Cummins and Midlo's method.[11]

The Dankmeijer (DI) and pattern intensity (PII) indices determined the digital variability of patterns. The DI is the total frequency of arches divided by the total frequency of whorls x100,[13] while the PII is the mean number of triradii found on toes per individual. Using those indices the frequencies of ridge patterns in the different digits were compared with normal patterns of Malawian subjects we had studied previously, matched for sex and age.

Inter-observer variation in counting was eliminated as only one 'blinded' person who did not collect the prints examined all the prints. Chi-square tests were applied to the variables of arches, whorls and loops while t-Tests were applied to the DI and PII variables.

Results

Plantar ridge patterns

a. Arches, loops and whorls: The soles of all patients showed more loops than arches and more arches than whorls. Whorls were restricted to the distal zones (Table 2a, c); loops and arches were more common on the proximal than distal zones of the sole.

b. Whorls: In hypertensive patients, whorls were only found in topographic zone I (Table 2b). In diabetes mellitus alone, whorls were found in zones I, II and III (Table 2a); in diabetes with hypertension, whorls were seen in zones I, III and IV (Table 2c)

Figure 1: Schematic topographical representation of the various zones of the sole of the foot

Figure 2: Footprint to illustrate arches, loops, whorls and triradii.

Digital ridge patterns

Arches were the most predominant ridge pattern in all patients followed by loops but whorls were absent.

a. Arches in the first digit: In diabetes alone, arches were absent; in hypertension, the arches were only present in women; in diabetes with hypertension, the arches were present in both sexes but in men it was confined to the right foot. Male hypertensive patients had no arches in the first digit (Table 3a, b, c).
b. Loops: Loops were only found in the first digit in all patients. The frequency of loops was highest in diabetes mellitus alone, high in diabetes with hypertension and least in patients with hypertension alone (Table 3a, b, c).

However none of these differences are statistically significant

Digital ridge patterns of patients and healthy Malawians

Table 4 compares the digital ridge variability in patients and healthy subjects, each disease category being compared separately. Both PII and DI indices were significantly different between patients and healthy subjects ($P< 0.001$), between males and females ($P<0.01$), but hypertensives did not show significant differences between the sexes ($P>0.5$) using PII. Diabetic patients had low mean DI when compared to all other groups.

Discussion

Plantar ridge patterns

We have reported probably for the first time in a black African sample the

Table1: Classification of zones of the sole of the foot using Cummins and Midlo's (1961) nomenclature

Topographical zone	Nomenclature	Topographical zone	Nomenclature
I	Hallucal	VI	Hypothenar distal
II	Second interdigital	VII	Hypothenar proximal
III	Third interdigital	VIII	Calcar (heel)
IV	Fourth interdigital	IX	Thenar proximal
V	Hypothenar distal	X	Thenar distal

Table 2: The mean frequency of whorls on the distal part of the sole expressed as a percentage

(a) Diabetes mellitus alone

Sex	*Limb*	*n*	Topographical zones					
			I	II	III	IV	V	VI
Men	Right	15	60.00	0.00	20.00	0.00	0.00	0.00
	Left	15	80.00	0.00	60.00	0.00	0.00	0.00
Women	Right	12	50.00	25.00	25.00	0.00	0.00	0.00
	Left	12	50.00	0.00	25.00	0.00	0.00	0.00
Men &	Right	27	55.56	11.11	22.22	0.00	0.00	0.00
Women	Left	27	66.67	0.00	44.44	0.00	0.00	0.00

(b) Essential hypertension alone

Men	Right	9	0.00	0.00	0.00	0.00	0.00	0.00
	Left	9	66.67	0.00	0.00	0.00	0.00	0.00
Women	Right	12	25.00	0.00	0.00	0.00	0.00	0.00
	Left	12	100.00	0.00	0.00	0.00	0.00	0.00
Men &	Right	21	14.29	0.00	0.00	0.00	0.00	0.00
Women	Left	21	85.71	0.00	0.00	0.00	0.00	0.00

(c) Diabetes mellitus with hypertension

Men	Right	21	42.86	0.00	0.00	0.00	0.00	0.00
	Left	21	42.86	0.00	0.00	14.29	0.00	0.00
Women	Right	30	40.00	0.00	20.00	0.00	0.00	0.00
	Left	30	40.00	0.00	20.00	10.00	0.00	0.00
Men &	Right	51	41.18	0.00	0.00	5.88	0.00	0.00
Women	Left	51	47.06	0.00	23.53	5.88	0.00	0.00

presence of whorls in the first topographical zone of the sole in hypertensive patients. Since this was not observed in healthy Malawians we studied previously[14] and in diabetics or in diabetics with hypertension, the finding would appear to suggest that plantar whorls are restricted to the first topographical zone of the sole in hypertension. This effect, however, seems to be masked where the hypertension co-exists with diabetes mellitus (Table 3). In the absence of other reports on blacks or blacks in Africa, this finding is difficult to explain. The report by Wilder[15] on plantar ridge patterns among Japanese, Chinese and European-Americans only considered healthy subjects. On the other hand, the studies by Wichman[16] and Komatz et al,[3]

reported on Caucasians, the former on healthy

Table 3: The frequency of loops and arches on toes expressed as a percentage

(a) Diabetes mellitus alone

Sex	Limb	n	Digits 1	2	3	4	5
Loops							
Men	Right	15	100.00	0.00	0.00	0.00	0.00
	Left	15	100.00	0.00	0.00	0.00	0.00
Women	Right	12	100.00	0.00	0.00	0.00	0.00
	Left	12	95.00	0.00	0.00	0.00	0.00
Arches							
Men	Right	15	0.00	100.00	100.00	100.00	100.00
	Left	15	0.00	100.00	100.00	100.00	100.00
Women	Right	12	0.00	100.00	100.00	100.00	100.00
	Left	12	0.00	100.00	100.00	100.00	100.00

(b) Essential hypertension alone

Loops							
Men	Right	9	100.00	0.00	0.00	0.00	0.00
	Left	9	66.67	0.00	0.00	0.00	0.00
Women	Right	12	50.00	0.00	0.00	0.00	0.00
	Left	12	50.00	0.00	0.00	0.00	0.00
Arches							
Men	Right	9	0.00	100.00	100.00	100.00	100.00
	Left	9	0.00	100.00	100.00	100.00	100.00
Women	Right	12	25.00	100.00	100.00	100.00	100.00
	Left	12	25.00	100.00	100.00	100.00	100.00

(c) Diabetes mellitus with hypertension

Loops							
Men	Right	21	71.43	0.00	0.00	0.00	0.00
	Left	21	71.43	0.00	0.00	0.00	0.00
Women	Right	30	90.00	0.00	0.00	0.00	0.00
	Left	30	100.00	0.00	0.00	0.00	0.00
Arches							
Men	Right	21	14.29	100.00	100.00	100.00	100.00
	Left	21	0.00	100.00	100.00	100.00	100.00
Women	Right	30	30.00	100.00	100.00	100.00	100.00
	Left	30	20.00	100.00	100.00	100.00	100.00

Table 4: Comparison of digital ridge variability between healthy subjects and patients with diabetes mellitus, hypertension and diabetes with hypertension in Malawians

Variables	Healthy Malawians⁺		Diabetes mellitus alone∗		Hypertension alone∗		Diabetes with hypertension∗	
	Men	Women	Men	Women	Men	Women	Men	Women
PII	7.65	6.66	9.80	11.00	10.00	10.00	9.86	8.90
DI	9.76	10.13	3.67	4.63	13.00	7.20	9.14	9.10

(Sources: ⁺ Igbigbi & Msamati 1999, ∗ Present study)

Note: PII and DI were calculated from pattern type frequencies; hence standard deviations were not obtained.

Germans and the latter on patients with Klinefelter's syndrome, respectively. Reports on black Africans are lacking, but we suggest that the effect could be genetic, racial or environmental.

The first topographical zone of the sole includes the first digit,[11] and corresponds to the hallucal zone used by Komatz et al,[3] These workers showed that patients with Klinefelter's syndrome exhibited special hallucal ridge patterns. The first topographical zone exhibited both plantar and digital features that could distinguish the three conditions in the present study. In hypertensive patients, whorls were only found in topographic zone I; in diabetes mellitus alone, whorls were found in zones I, II and III; and in diabetes with hypertension, whorls were seen in zones III, IV and I (Table 2a, b, c). It would appear from this study that plantar whorls showed disease better in our series.

The prominence of digital arches and loops in all patients sampled in this study merely confirms the observations in healthy Malawians, where whorls were also absent on all digits, highlighting further the peculiarity of black Malawians.[14] We have also demonstrated that loops were restricted to the first digit in the three categories of patients, a finding that again differentiates these patients from healthy subjects. We have reported for the first time in black Malawians that patients with diabetes alone showed the highest frequency of loops than diabetics with hypertension, and those with hypertension alone (Table 3). We believe this trend could only be due to genetic influences by these diseases.

The complete absence of arches on the first digit of diabetes mellitus patients differentiates them from healthy individuals. It was interesting, however, to note that the arches were present in the first digit when diabetes co-existed with hypertension (Table 3). Furthermore, in hypertension, the arches were only present in women, while in diabetes with hypertension, the arches were present in both sexes but confined to the right foot in men (Table 3a, b, c). On the other hand, the fact that the frequency of loops was highest in diabetes mellitus, high in diabetics with hypertension and least in patients with hypertension alone (Table 3a, b, c), suggests that loops differentiated diabetes mellitus, essential hypertension and diabetes with hypertension better than arches.

The digital ridge patterns indicated above were further confirmed by the PII and DI indices. Using these indices, the patients were correctly classified into the three categories of patients in our series and the groups were found to differ from healthy Malawians. These findings become important when one realises that epidermal ridge patterns form early in fetal life and remain unchanged throughout life.[4] Could they therefore serve as reliable indicators of genetic abnormality? Using palmar and digital dermatoglyphics a number of studies have indicated that indeed this is the case with diabetes mellitus.[4,5,9] The present findings suggest that the same could also apply to the ridge patterns of the sole.

Plantar dermatoglyphics have received relatively little attention when compared to palmar ridge patterns. This has been attributed to the difficulty of obtaining prints and classifying them from the soles when compared to those from palms. For this reason little attention has been given to studies of plantar and digital ridge patterns of hereditary diseases like diabetes and hypertension from the sole. Notwithstanding this, genetic, racial, sexual and regional differences have been exhibited by the sole from the few studies of other racial groups on healthy subjects.[15,16] Studies in sub-Saharan Africa have examined healthy indigenous black Malawians[14] and Nigerians.[17,18] On the other hand, Komatz et al,[3] studied the hallucal ridge patterns for the clinical diagnosis of patients with Klinefelter's syndrome. However, there appear to be no other published reports on plantar and digital ridge patterns in genetic diseases in Africans.

Conclusion

This study has highlighted differences in plantar and digital dermatoglyphic features between patients and healthy Malawians. The differences exhibited were demonstrated better in digital than in plantar ridge patterns. The specific ridge patterns that have emerged from this study showed that whorls in the topographical zones I – IV of the sole as well as the presence and frequency of loops in the first digit, were indicators of these conditions. We suggest that these findings could be used to predict the occurrence in later life of diabetes mellitus, hypertension and hypertension with diabetes in children in Malawi.

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