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PLANTAR DERMATOGLYPHICS IN DOWN SYNDROME

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ABSTRACT
Dermatoglyphics is a useful tool in the preliminary investigation of some conditions with suspected genetic basis. The study examines the dermatoglyphic features of 130 (100 normal and 30 Down syndrome) subjects. The prints were collected by a digital electronic scanner. The parameters investigated were the frequency distribution of dermal ridge patterns such as arches, fibular loops, inverted loops, upright loops, vestiges and whorls in each zone of the sole. Chi-square test was used to determine significant difference in the distribution of these patterns between normal subjects and Down syndrome patients. The result shows the predominance of open field in Zones I and II of the sole of Down syndrome patients while normal subjects had more of whorls in Zone I, inverted loops in Zone II and upright loops in zone III. There is significant difference ($p>0.05$) in the distribution of the dermal ridge pattern in Zones I, II, III, IV and VI. The result could be useful to clinicians for early diagnosis of Down syndrome.

Key Words: Plantar dermatoglyphics, Down syndrome, Dermal ridge, Whorl, loop

INTRODUCTION

The entire human body is covered with skin which varies in thickness and texture in different parts of the body. The skin that covers the anterior surface of human hand and the plantar surface of the human foot is thicker and continuously wrinkled with narrow minute ridges also known as friction ridges. Friction ridged skin is not only confined to the plantar and palmar surfaces but other areas such as the lip, toes, fingers and other areas. (Kumbnani, 2007).The study of ridge patterns of the skin is the basis for dermatoglyphics. The term dermatoglyphics, coined by Cummins and Midlo (1926), is simply defined as the study of the patterns of epidermal ridges of the skin found on the fingers, palms of the hands, sole of the feet and lips (Cummins and Midlo, 1943). The ridges and creases have great significance in determining the characteristics of human beings due to their developmental origin, permanency, variability and inability to change (Shier *et*

al., 1999; Kumbnani, 2007; Babler *et al*., 1991). Cummins and Midlo (1943) reported that the characteristics of the original ridge are not disturbed unless the skin is damaged to a depth of about one millimetre.

Dermatoglyphics over the years have therefore become a useful tool in medicine, genetics and forensics (Rajangam *et al.,* 1995; Bryant *et al.,* 1970; Oladipo *et al.,* 2010). It played significant role in preliminary investigations into conditions with suspected genetic basis such as Turner's syndrome, Klinefelter's syndrome, Autism, Down's syndrome and others. (Nazarabadi *et al.,* 2007; Oghenemavwe *et al.,* 2015; Oladipo *et al*., 2013; Bryant *et al.,* 1970; Kiran *et al.,* 2010; Boroffice *et al.,* 1978) and also served in the resolution of medico-legal cases that involved paternity dispute (Hellwig, 1912; Harster, 1913)

Down's syndrome or Trisomy 21 is a chromosomal disorder caused by the presence of an extra copy of chromosome 21 and is the most common chromosomal anomaly in humans. Individuals with this genetic defect present phenotypic manifestations such as a flat face with small nose, upward slant eyes, low muscle tone (floppiness noticeable in babies), excessive ability to extend the joint, a large tongue that tends to stick out, an extra space between the big and small toes and simian crease (Reed, 1991; Walker, 1958). Down (1909) was the first to note the increase frequency of a single transverse palmar crease (Simian Crease) in the patients hence it is called Down's syndrome. As a follow up, Walker (1958) developed the first practical diagnostic index for Down's syndrome patients using only dermatoglyphic features of the palm. At present, the dermal ridge patterns of the palm in these patients are well known but the same cannot be said for the sole of the foot as researches on dermatoglyphic patterns of sole of the feet are very rare. Therefore, the aim of this study is to evaluate the dermatoglyphic patterns of the sole of the foot in some Nigerians with Down's syndrome

MATERIALS AND METHODS

A total of 130 subjects (30 Down syndrome patients [DS] and 100 normal subjects [N]) were randomly selected for the study. The 30 DS patients comprised 17 females and 13 males and the normal subjects comprised 35 females and 65 males. using the method described by Tushar (2010). The subjects were all from special and public schools in Rivers State and Federal Capital Territory, Abuja. The schools for DS subjects include OLG Health Foundation Port Harcourt, The Child Special School Port Harcourt, Hope House Initiative for Children with Learning Difficulties, Maitama-Abuja and Abuja School for the handicapped located at the suburb, Kuje. The normal subjects were from the University of Port-Harcourt Demonstration Secondary School and Choba Community School, both in River State. Subjects included in this study were those without feet deformities. Ethical clearance was obtained from the Ethics Committee of the University of Port Harcourt and all institutions involved in the research. In addition, written informed consent was also given by parents/guardian of subjects.

The prints were collected using the method described by Oghenemavwe and Osaat (2015) and all analyses were done by the

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principal investigator. Digital electronic scanner and computer based analyses were employed. To obtain the prints, subjects were required to wash their soles with soap and water. The washed feet were then dried with towel to avoid dirt distorting the prints. Feet were placed in the scanner and the digital images taken and transferred to a computer (see figure 1). The classification of Cummins and Midlo's (1961) was used to categorize the dermatoglyphic patterns of the different zones of the sole. The parameters investigated were the frequency distribution of dermal ridge patterns such as arches, fibular loops, inverted loops, upright loops, vestiges and whorls in each zone of the sole. Chi-square test was used to determine significant difference in the distribution of these patterns between normal subjects and Down syndrome patients.

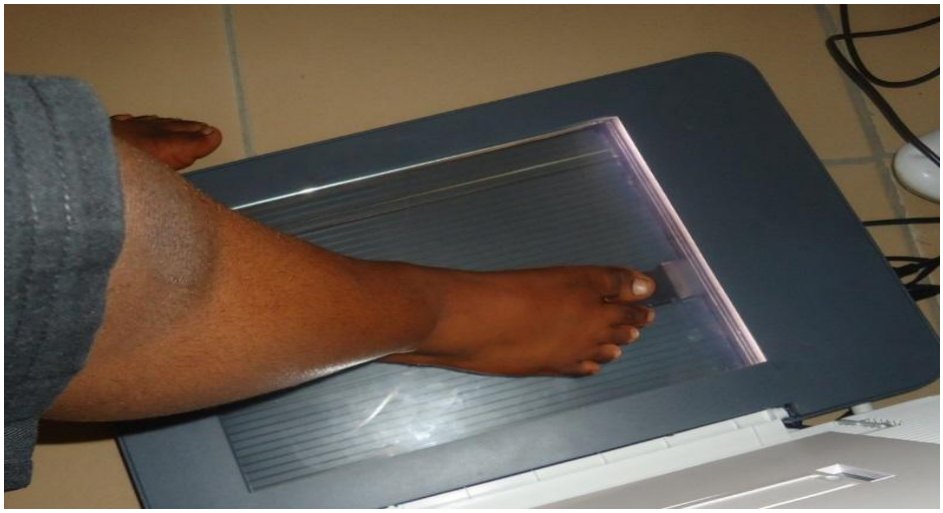

Figure 1: Diagram showing the scanning of the foot

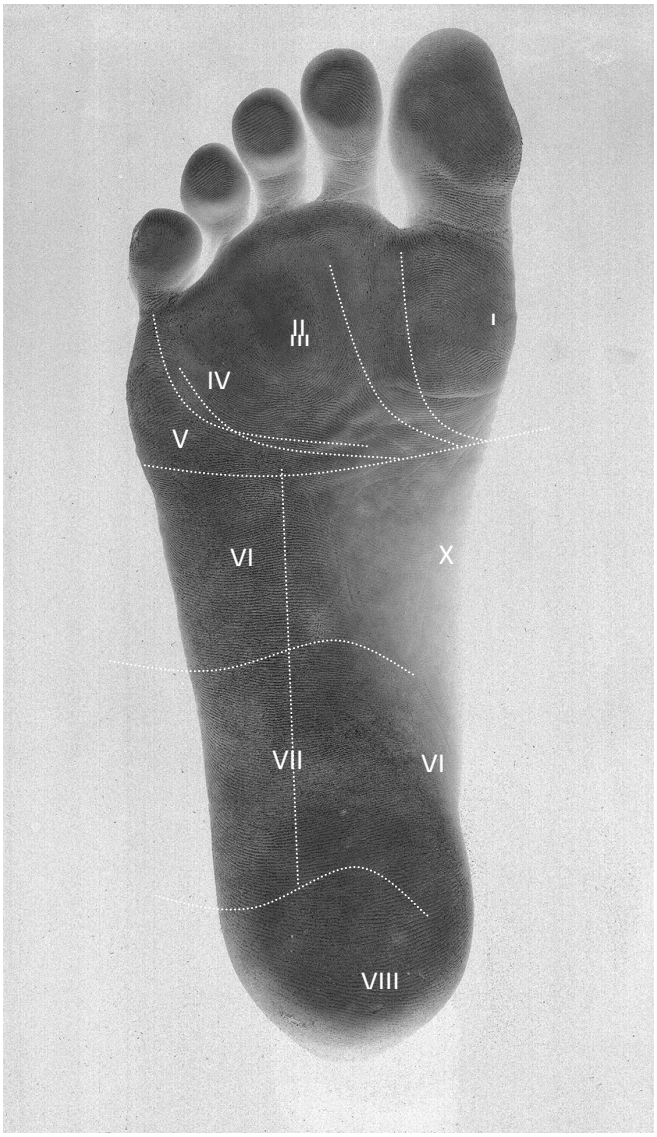

Figure 2: Image showing the zones of plantar surface of the scanned foot

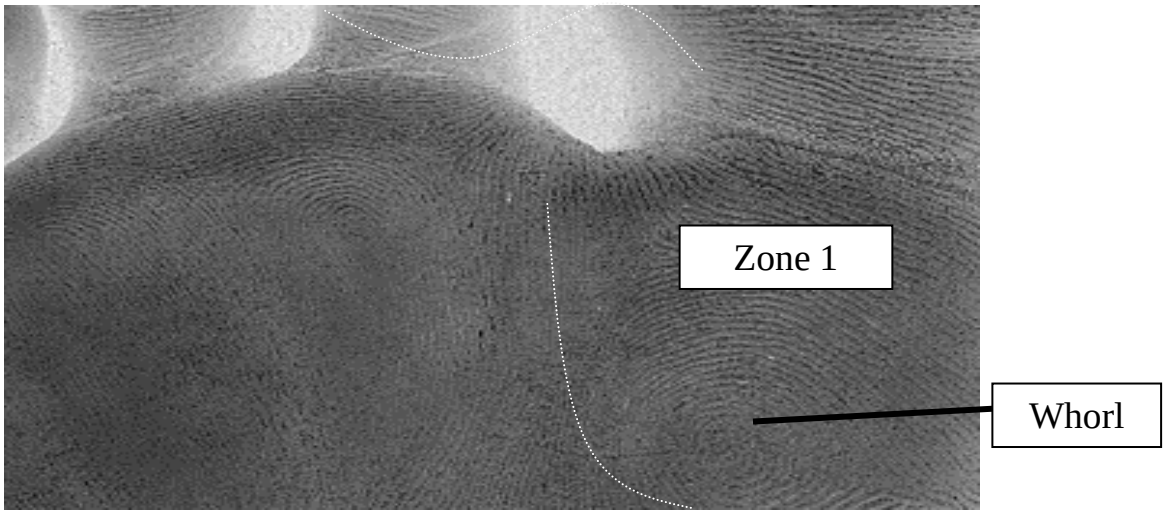

Figure 3: A magnified image of zone I showing whorl pattern

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RESULTS

Gross morphological appearance

The arches of the foot appear normal. There is no pes planus or pes carvus in any of the DS subject. Unlike in the palm where there is frequent occurrence of simian crease (a single crease that transverse the whole palm) the sole has none. The evaluations of the feet exclude morphometric analyses.

Dermatoglyphic pattern of the sole irrespective of gender

The results (irrespective of gender)of dermatoglyphic patterns are shown in tables 1 and 2.There are more of whorl patterns in zone 1, inverted loops in Zone II, upright loops in zone III and open fields in zone IV in normal subjects. Open fields are more in Zones I, II, IV, V, VI, VII, VIII, IX and X in the soles of DS. The presentations of the dermatoglyphic patterns are similar in both feet of normal and DS subjects.

Dermatoglyphic pattern of the sole based on of gender

The results based on gender are presented in tables 3 to 6. In zone 1, the distribution of open fields, tibial loops, upright loops and whorls differ significantly ($p<0.05$) in both gender for normal and DS. Whorl patterns are the highest in this zone for normal subjects while open fields are the highest in DS. Inverted loops, open fields, upright loops and whorls are the common patterns in zone II. Normal subjects have more of inverted loops in both gender while DS have more of open fields. There is complete bilateral absence of upright loop in male DS in this zone. The distribution of the dermatoglyphic patterns differ significantly ($p<0.05$). In Zone III, inverted loops are completely absent in DS males but present in the right foot of DS females. On the contrary, inverted loops appear in both gender in normal subjects. Upright loops are more in DS than normal subjects. The distribution of the dermatoglyphic patterns between DS and normal subjects differ significantly ($p<0.05$) in this zone.

The dermatoglyphic patterns in Zone IV for both groups are inverted loops, open fields, upright loops and whorls but the frequency of open fields are more than other dermal ridge patterns. The distribution of these patterns differ significantly ($p<0.05$) only in the females. Zones V, VII, VIII, IX and X have more of open fields and distribution of the dermatoglyphic patterns are not significantly different in the two groups ($p>0.05$) except in Zone VII of the right foot in females. In Zone VI, there is a significant difference in the way the dermal ridge patterns are distributed in normal and DS except only in the left feet of male subjects.

Table 1: Distribution of dermatoglyphic pattern in the right foot of all normal and DS subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III*	IV*	IV*	V	V
Arches	0	0	0	0	0	0	5	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	71	20	7	3.34	5	13.34	0	0
Open fields	6	43.33	24	76.67	16	43.33	76	53.33	100	93.33
Tibial loop	15	3.34	0	0	0	0	0	0	0	6.67
Upright loops	4	30	4	3.33	58	53.33	13	33.33	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	75	23.33	1	0	19	0	1	0	0	0

* = ($p<0.05$)

Table 1: Distribution of dermatoglyphic pattern in the right foot of all normal and DS subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI	VI	VII	VII	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	0	0	0	0	0	0	0	0
Open fields	74	50	95	100	100	100	82	83.33	83	86.67
Tibial loops	26	50	5	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	18	16.67	17	13.33
Whorls	0	0	0	0	0	0	0	0	0	0

Table 2: Distribution of dermatoglyphic pattern in the left foot of all normal and DS subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III	IV	IV	V	V
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	69	20	9	3.33	10	3.34	0	0
Open fields	7	46.67	26	76.67	19	40	74	70	100	90
Tibial loops	13	0	0	0	0	0	0	0	0	10
Upright loops	3	23.33	4	3.33	48	50	12	23.33	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	77	30	1	0	24	6.67	4	3.33	0	0

* = ($p<0.05$)

Table 2: Distribution of dermatoglyphic pattern in the left foot of all normal and DS subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI	VI	VII	VII	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	0	0	0	0	0	0	0	0
Open fields	74	63.33	97	100	100	100	82	83.33	83	86.67
Tibial loops	26	36.67	3	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	18	16.67	17	13.33
Whorls	0	0	0	0	0	0	0	0	0	0

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Table 3: Distribution of dermatoglyphic pattern in the right foot of normal and DS male subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III*	IV	IV	V	V
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	69.23	23.08	7.69	0	7.69	7.69	0	0
Open fields	6.15	53.85	24.61	76.92	15.38	38.46	73.85	69.23	100	92.31
Tibial loops	15.38	7.69	0	0	0	0	0	0	0	7.69
Upright loops	3.09	15.38	4.62	0	53.85	61.54	16.92	23.08	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	75.38	23.08	1.54	0	23.08	0	1.54	0	0	0

* = ($p<0.05$)

Table 3: Distribution of dermatoglyphic pattern in the right foot of normal and DS male subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI*	VI*	VII	VII	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	66.15	0	0	0	0	0	0	0	0	0
Open fields	33.85	61.54	93.85	100	100	100	75.38	76.92	80	76.92
Tibial loops	0	38.46	6.15	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	24.62	23.08	20	23.08
Whorls	0	0	0	0	0	0	0	0	0	0

* = ($p<0.05$)

Table 4: Distribution of dermatoglyphic pattern in the left foot of normal and DS male subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III*	IV	IV	V	V
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	67.7	30.77	7.69	0	12.31	0	0	0
Open fields	6.15	53.85	26.15	69.23	18.46	38.46	69.23	92.31	100	92.31
Tibial loops	13.85	0	0	0	0	0	0	0	0	7.69
Upright loops	1.54	15.38	6.15	0	49.23	53.85	15.38	7.69	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	78.46	30.77	0	0	24.62	7.69	3.08	0	0	0

* = ($p<0.05$)

Table 4: Distribution of dermatoglyphic pattern in the left foot of normal and DS male subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI	VI	VII	VII	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	0	0	0	0	0	0	0	0
Open fields	66.15	53.85	96.92	100	100	100	84.62	76.92	87.69	84.62
Tibial loops	33.85	46.15	3.08	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	15.38	23.08	12.31	15.38
Whorls	0	0	0	0	0	0	0	0	0	0

Table 5: Distribution of dermatoglyphic pattern in the right foot of normal and DS female subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III*	IV*	IV*	V	V
Arches	0	0	0	0	0	0	14.29	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	74.29	17.65	5.71	5.88	0	17.64	0	0
Open fields	5.71	35.29	22.86	76.47	17.15	47.06	80	41.18	100	94.12
Tibial loops	14.29	0	0	0	0	0	0	0	0	5.88
Upright loops	5.71	41.18	2.85	5.88	65.71	47.06	5.71	41.18	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	74.29	23.53	0	0	11.43	0	0	0	0	0

* = ($p<0.05$)

Table 5: Distribution of dermatoglyphic pattern in the right foot of normal and DS female subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI*	VI*	VII	VII	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	0	0	0	0	0	0	0	0
Open fields	88.57	41.18	97.14	100	100	100	94.29	88.24	88.57	92.31
Tibial loops	11.43	58.82	2.86	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	5.71	11.76	11.43	7.69
Whorls	0	0	0	0	0	0	0	0	0	0

* = ($p<0.05$)

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Table 6: Distribution of dermatoglyphic pattern in the left foot of normal and DS female subjects

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	I*	I*	II*	II*	III*	III*	IV*	IV*	V	V
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	71.43	11.76	11.43	0	5.71	5.88	0	0
Open fields	8.57	41.18	25.71	82.36	20	41.18	82.86	52.94	100	88.24
Tibial loops	11.43	0	0	0	0	0	0	0	0	11.76
Upright loops	5.71	29.41	0	5.88	45.71	52.94	5.71	35.3	0	0
Vestiges	0	0	0	0	0	0	0	0	0	0
Whorls	74.29	29.41	2.86	0	22.86	5.88	5.71	5.88	0	0

* = ($p<0.05$)

Table 6: Distribution of dermatoglyphic pattern in the left foot of normal and DS female subjects (cont'd)

PATTERNS	N	DS	N	DS	N	DS	N	DS	N	DS
Zones	VI*	VI*	VII*	VII*	VIII	VIII	IX	IX	X	X
Arches	0	0	0	0	0	0	0	0	0	0
Fibular loops	0	0	0	0	0	0	0	0	0	0
Inverted loops	0	0	0	0	0	0	0	0	0	0
Open fields	88.57	41.18	97.14	100	100	100	94.29	94.12	91.43	123.08
Tibial loops	11.43	58.82	2.86	0	0	0	0	0	0	0
Upright loops	0	0	0	0	0	0	0	0	0	0
Vestiges	0	0	0	0	0	0	5.71	5.88	8.57	7.69
Whorls	0	0	0	0	0	0	0	0	0	0

* = ($p<0.05$)

DISCUSSIONS

This study has investigated plantar dermatoglyphic patterns in Down's syndrome patients in Nigeria. Just before the dawn of the century, research interest in dermatoglyphic was extended into diseases especially those of genetic origin. The postulation was that since genes influence the formation of ridge pattern of the skin, they may also be used as a diagnostic tool for diseases of genetic origin (Walker, 1964; David, 1981; Marko, 1992). The dermal features of the palm in DS have given credibility to this postulation. One basic criterion in the preliminary determination of DS is the presence of simian crease in the palm. While dermal features of the palm in DS were extensively studied and reported, the same cannot be said for the sole (Boroffice, 1978; Bryant *et al*., 1970; Down, 1907; Nazarabadi *et al*., 2007; Reed, 1991). A possible explanation may be the difficulty in proper elucidation of the features of the sole. From experience, the use of the ink method in studying the sole more often produce poor print due to the difficulty in

controlling the impressions at the time they are taken. This is more so in patients with any form of mental retardation. The improvised digital method in this research has aided us in overcoming this difficulty.

This research work has revealed that the dermatoglyphic patterns of normal and DS patients differ significantly in Zone I of the sole. The whorl patterns are the most frequent in normal subjects when compared with DS patients which have more of an open field. Our findings contrast that of Fox and Plato, 1987 who reported more of upright loops in this zone. The significant difference of the dermal patterns in Zone I of the foot could be a useful preliminary criterion for the diagnosis of DS. As already noted, the highest occurring dermal pattern in Zone II for normal subjects is upright loop for normal subjects and open fields for DS. There are more of whorls in Zones II and III in patients with diabetes mellitus and in Zones IV in patients with diabetes mellitus and hypertension amongst Malawians (disease, Igbigbi *et al.*, 2001)

The findings of this research agree with the study by Fox and Plato (1987) that there are more of open fields in Zone IV. Open fields are patterns of less linear ridges which appear as rays of depressions with smooth bases. They are more in the lower limb than the upper limb. The reason may be attributed to the time of development, as the lower limbs develop two days after the upper limb had begun **(**upper limb starts developing at 28 days) (Sadler, 2012).The extensive presence of open fields in DS could be as a result of the interplay between time of development and alteration in the chromosome 21. The reverse pattern of occurrence of tibial loops and open fields in Zones V and VII of DS and normal subjects is another major difference that could be used in the preliminary investigation. Zones VIII, IX and X are also known as the Calcar and Thenar Zones. The research by Siemens (1954) shows that more than ninety-nine percent of these zones is characterized by open fields and a few vestiges. Our result shows the same, both in normal and Down syndrome subjects. Most importantly, the dermatoglyphic features of these zones cannot be used in the preliminary diagnosis of DS.

The present study has established dermatoglyphic differences in normal and Down syndrome subjects of Nigeria. Some of these differences included the predominance of open field in Zone I and II of Down syndrome subjects compared to normal subjects and significant difference in the distribution of dermatoglyphic patterns in Zones I-IV

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