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Original Research Article

Plantar Dermatoglyphics of Down's Syndrome and Healthy Subjects of Nigeria

Roseline Sunday Osaat[1]*

[1]Department of Anatomy, Faculty of Basic Medical Sciences, Federal University Otuoke, Bayelsa State, Nigeria

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Abstract: The study of the foot print which is known as plantar dermatoglyphics has been in existence for decades. Like fingerprints, no two persons have the same footprints. The study aimed at determining the plantar dermatoglyphics of Down's syndrome and healthy subjects of Nigeria. The study comprised of 201subjects, 101 (58 males and 43 females) Down syndrome and 100 (65 males, 35 females) control subjects. The study was conveniently carried out in some special schools in Lagos, Abuja and Port Harcourt. The healthy subjects were gotten from University of Port Harcourt Demonstration Secondary School. The subjects were selected using a scanning method according to Oghenemavwe & Osaat (2015) and chi-square test was used to analyzed the sole of the foot and the big toe. The results revealed significant differences between Down's syndrome subjects and control subjects in zone I to IV (right hand) and I to III, V (left hand) for both sexes and the big toe bilaterally. Down's syndrome had increased frequency of distal and proximal loop on zones I and II respectively ($p<0.05$), increased frequency of open field on zones I to III ($p<0.05$). However, a significant increase was observed in whorl for control subjects when compared to Down's syndrome subjects ($p<0.05$). The difference across the pattern in the big toe between Down's syndrome and control subjects was significant with Down's syndrome having more of whorl than control subjects ($p<0.05$). The study suggested plantar dermatoglyphics a supportive method that could be useful in screening Down's syndrome for early intervention.

Keywords: Plantar Dermatoglyphics, Down's syndrome, Big Toe, Distal Loop, Whorl.

INTRODUCTION

Dermatoglyphics is derived from two Greek words "derma" means skin and "glyph" means carve and it is the scientific study of epidermal ridges of skin on both fingerprints and footprints (Moore & Persuad, 2003). The science of dermatoglyphics is based on two major facts: first, the ridges are slightly different for different fingers and no two persons, not even the monozygotic twins, show exactly similar fingerprint patterns, and second, the ridges are permanent throughout life (Singh *et al.,* 2016). Dermatoglyphics can be used to differentiate between different races or population (Osunwoke *et al.,* 2008). During the early month of fetal development when the ridges are in the process of formation, certain disturbances of fetal growth during this period, which could be either under genetic control or influenced by environmental factors are able to modify the ridge configurations, because once a pattern is established it can never be altered except increase in size (Walker, 1977).The Development of dermatoglyphic patterns is under genetic control but can in one way or the other be influenced by environmental factors (Bhat *et al.,* 2014). This can be seen in the study of monozygotic twins which reveal a close resemblance in dermatoglyphic patterns (Reed *et al.,* 1975). This invariably shows genetic control and the least influences of other environmental factors.

The term dermatoglyphics was first used by Dr. Harold Cummins, however, so many scientists are involved in the scientific research of fingerprint for decades back. Many countries like India, Japan, UK were making use of fingerprints since then. In 1823, Johannes Evangelista Purkinje was credited as the first to begin the scientific study of papillary ridges of the hands and feet, (Campbell, 1998). He systematically categorized fingerprint patterns into nine fingerprint patterns. However, after him, not much was done with respect to fingerprints.

Plantar dermatoglyphics is the study of foot-prints. The study of footprints has been in existence for decades like fingerprints, though because of the

***Corresponding Author:** Roseline Sunday Osaat
Department of Anatomy, Faculty of Basic Medical Sciences, Federal University Otuoke, Bayelsa State, Nigeria

difficulty of getting the prints not so many researchers have delved into studying footprints (Verbov, 1970; Tewari & Bhasin, 1971). And as such it applications were limited in clinical use especially for diagnosis. However, there is still need to devise a suitable method of classifying the foot prints for easy study.

Two methods have been proposed for footprints, one by Cummins and the other by Wilder (Montgomery, 1927). According to Cummins and Midlo, the sole was mapped into ten topographical zones (Cummins & Midlo, 1961). Zones I-V represented the distal plantar sole and zones VI-X represented the proximal plantar sole (Igbigbi & Msamati, 2001).

Down's syndrome (DS) is a chromosomal condition that is caused by the presence of all or part of a third copy of chromosome twenty one (21) and so it is also called trisomy 21, (Gordon, 2010; Butter & Meaney, 2005). It is typically associated with a delay in cognition ability (mental retardation) and physical growth with a particular set of facial characteristics. A large number of individuals with Down's syndrome have a severe degree of intellectual disability.

The study investigated the plantar dermatoglyphics of Down's syndrome subjects and Healthy subjects in a Nigeria population.

METHODOLOGY

Research Design

The design for this research is the descriptive sample survey method used to investigate the plantar dermatoglyphic patterns of Down's syndrome subjects in a Nigerian population. This research was carried out in some selected cities in Nigeria such as Lagos, Abuja and Port Harcourt. This study comprised both male and female of Down's syndrome subjects in Nigeria. Age ranged between 5 to 35 years of .

Sample Size Determination

Sample size was determined using the prevalence rates. Adeyokunnu (1982) reported a prevalence rate of 1 in 865live births for Down's syndrome. Using Cochran formula (Daniel, 1999), the minimum sample size got for Down's syndrome was 49, however the sample size used for this research study was 101(58 males and 43 females) for Down's syndrome subjects and 100 (65 males and 35 females) for Healthy subjects.

Sampling Technique and Subjects Selection

The sampling technique used for this research was convenience sampling technique. This is as a result of the difficulty in getting the children due to fear of stigmatization. The subjects who met the inclusion criteria were selected from the study areas. Information needed for the selection of the subjects was obtained directly from the occupational therapists, care-givers or teachers which were supported by the physical observations of the researcher. An informed consent which contains details of the research work was issued out and clarifications given were necessary before the commencement of work.

Inclusion and Exclusion Criteria

The subjects must be or Down's syndrome living in Nigeria who volunteered through their parents or institutional authorities to participate in the study, with no form of trauma or anomaly in their palms and feet. Those with hand or foot anomaly, those who have undergone any surgical procedure on hand and foot which disrupt the ridges, other forms of disorder outside Down's syndrome, and children whose parents did not give consent to the procedure were all excluded from the study.

Method of Data Collection and Determination

The dermatoglyphic patterns were collected and determined using the scanning method precisely High-resolution digital scanner according to Oghenemavwe & Osaat (2015). The method involves using a digital scanner (Hewlett-Packard (hp) G3110 Scanjet Scanner with 4800x9600 dpi resolution) connected to a laptop to identify and classify dermatoglyphics. The scanner and laptop were both electrically powered using any electrical source.

For those subjects that were not on shoes or socks, their feet and soles were thoroughly washed with water and soap and dried with clean towel to remove dirt. While those with shoes or socks were asked to remove their footwear and place it on the scanner and accordingly the feet and soles were scanned. The scanned images were saved in a folder and named appropriately. Later on, collation of raw data was obtained from the scan images and used for further analysis.

Zone I is hallucal, zone II is second inter-digital, zone III is third inter-digital, zone IV is fourth inter-digital, zone V is hypothenar distal, zone VI is hypothenar distal, zone VII is hypothenar proximal, zone VIII is calcar (heel), zone IX is thenar proximal and zone X is thenar distal.

The sole of the foot has the following patterns: Upright loop opening distally (L^d), Inverted loop opening proximally (L^p), Tibial loop opening tibially (L^t), Fibular loop opening fibularly (L^f), Whorl: it is of three types. Concentric whorl (W), Spiral whorl (W^s) and Seamed whorl (W^{sm}), Open fields (O) these are succession of parallel ridges, straight or but gently curved. They form no pattern, Arches open proximally (A^p), tibially (A^t) and distally (A^d), and Vestiges: which lack the sharp recurvature of ridges that distinguish true patterns (Siemens, 1954).

Method of Data Analysis

The data obtained from this study were subjected to test using SPSS (Statistical Package for Social Science IBM ® Version 23 New York). Chi-square test was used to test for association. All statistical testing was done at 95% confidence level with p-value less than 0.05($p< 0.05$) taken to be significant.

Ethical Consideration

Prior to commencement of the research work, ethical approval was sought from the Research Ethics Committee of the School of Graduate Studies, University of Port Harcourt in form of proposal writing and it was approved with reference number UPH/CEREMAD/REC/04. In addition, informed consent was obtained from the parents/guidance and institutional authorities of the subjects by signing a consent form given to them before samples of the subjects under study were taken.

RESULTS

Table 1a showed the right foot patterns in Down's syndrome and normal subjects of both sexes. The result revealed that, in the right hallucal area (zone I), Down's syndrome subjects have more of distal loop (26.7%) than normal subjects (6%) and more of proximal loop than normal subjects. Whorl was significantly increased in the hallucal area of normal (73%) than Down's syndrome (16.8%) subjects. In the second interdigital area (II), proximal loop and open field were significantly higher in Down's syndrome than normal subjects. While whorl patterns in both Down's syndrome than normal subjects have the same distribution. Distal loop was higher in normal subjects than Down's syndrome subjects. The differences were significant. In the third interdigital area (zone III), distal loop, proximal loop and whorl (46%, 6% and 23% respectively) were higher in Down's syndrome subjects than normal subjects (38.6%, 5.9% and 2% respectively). In the fourth interdigital area (zone IV), distal loop was higher in Down's syndrome than normal subjects. Proximal loop was higher in normal subjects that Down's syndrome subjects. In the hypothenar distal (zone V), distal loop and proximal loop were absent in both Down's syndrome and normal subjects, however, tibial loop has equal distribution in both Down's syndrome and normal subjects. There were more percentages of open field in Down's syndrome subjects than control subjects which was significant. The distal plantar surface of the sole showed significant difference in the distribution of patterns between Down's syndrome subjects and normal subjects of both sexes on both feet, (zones I-IV). In the proximal plantar surface ie from VI – X zones, there were more untrue patterns like vestiges and open fields/arch and they showed no statistical difference between Down's syndrome and normal subjects $p>0.05$. For the big toe, Down's syndrome has higher percentage of fibular loop 69.3% and whorl 18.8% than normal subjects which has fibular loop 62% and whorl 5%, while normal subjects have more of arches than Down's syndrome subjects. These differences were significant $p<0.05$. On the left foot of Down's syndrome and normal subjects (table 1b), the hallucal (zone I), second (II) and third interdigital (III) areas and the hypothenar distal area (zone V) were significantly different between Down's syndrome and normal subjects. The big toe was significantly different similar to the right foot.

Table 2a showed that zones I to III and the big toe were statistically different between male Down's syndrome and normal on the right foot. While on the left (table 2b) zones I – III and the big toe were significantly different between the male subjects ($p<0.05$). In table 3a, the female Down's syndrome and normal subjects were significantly different on the right foot from each other in the hallucal (I) area, second (II), third (III) and fouth (IV) interdigital areas ($p<0.05$), while other areas especially the proximal surface were not statistically significant including the hypothenar distal (zone V) ($p>0.05$). On the left foot, table 3b, zones I and III showed significant difference.

Table 1a: Right foot patterns in Down's syndrome and Normal Subjects of both sexes

Right Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X^2	df	P-value
I	DS FOOT	27 (26.7)	1 (1.0)	1 (1.0)	0 (0.0)	-	17 (16.8)	52 (51.5)	3 (3.0)	100.96	6	**0.00****
	NO FOOT	6 (6.0)	0(0.0)	14 (14.0)	1 (1.0)	-	73 (73.0)	6 (6.0)	0 (0.0)			
II	DS FOOT	1 (1.0)	18 (17.8)	-	-	-	2 (2.0)	80 (79.2)	-	64.13	3	**0.00****
	NO FOOT	44 (44.0)	0 (0.0)	-	-	-	2 (2.0)	54 (54.0)	-			
III	DS FOOT	39 (38.6)	6 (5.9)	-	-	-	2 (2.0)	54 (53.5)	-	28.86	3	**0.00****
	NO FOOT	46 (46.0)	6 (6.0)	-	-	-	23 (23.0)	25 (25.0)	-			
IV	DS FOOT	36 (35.6)	6 (5.9)	-	-	-	0 (0.0)	59 (58.4)	-	13.42	3	**0.00****
	NO FOOT	14 (14.0)	9 (9.0)	-	-	-	1 (1.0)	76 (76.0)	-			
V	DS FOOT	-	-	3 (3.0)	-	-	-	95 (94.1)	3 (3.0)	2.99	2	0.22
	NO FOOT	-	-	3 (3.0)	-	-	-	96 (97.0)	0 (0.0)			
VI	DS FOOT	-	-	31 (30.7)	-	-	-	69 (68.3)	1 (1.0)	1.00	2	0.61
	NO FOOT	-	-	31 (31.0)	-	-	-	69 (69.0)	0 (0.0)			
VII	DS FOOT	-	-	3 (3.0)	-	-	-	98 (97.0)	-	3.25	1	0.08
	NO FOOT	-	-	9 (9.0)	-		-	91 (91.0)	-			
VIII	DS FOOT	-	-	-	-	-	-	99 (98.0)	2 (2.0)	2.00	1	0.50
	NO FOOT	-	-	-	-	-	-	100 (100.0)	0 (0.0)			
IX	DS FOOT	-	-	-	-	-	-	86 (85.1)	15 (14.9)	1.64	1	0.28
	NO FOOT	-	-	-	-	-	-	91 (91.0)	9 (9.0)			
X	DS FOOT	4 (4.0)	-	-	2 (2.0)	-		81 (80.2)	14 (13.9)	6.25	3	0.10
	NO FOOT	0 (0.0)	-	-	0 (0.0)	-	-	87 (87.0)	13 (13.0)			

Right Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X^2	df	P-value
Big Toe	DS FOOT	-	-	-	70 (69.3)	12 (11.9)	19 (18.8)	-	-	18.45	2	**0.00****
	NO FOOT	-	-	-	62 (62.0)	33 (33.0)	5 (5.0)	-	-			

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant

Table 1b: Left foot patterns in Down's syndrome and Normal Subjects of both sexes

Left Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X^2	df	P-value
I	DS FOOT	24 (23.8)	-	0 (0.0)	-	-	19 (18.8)	55 (54.5)	3 (3.0)	93.39	4	**0.00****
	NO FOOT	6 (6.0)	-	12 (12.0)	-	-	74 (74.0)	8 (8.0)	0 (0.0)			
II	DS FOOT	1 (1.0)	17 (16.8)	-	-	-	0 (0.0)	83 (82.2)	-	17.943	3	**0.00****
	NO FOOT	1 (1.0)	43 (43.0)	-	-	-	1 (1.0)	55 (55.0)	-			
III	DS FOOT	41 (40.6)	5 (5.0)	-	-	-	3 (3.0)	51 (50.5)	1 (1.0)	26.04	4	**0.00****
	NO FOOT	40 (40.0)	6 (6.0)	-	-	-	26 (26.0)	28 (28.0)	0 (0.0)			
IV	DS FOOT	23 (22.8)	9 (8.9)	1 (1.0)	-	-	0 (0.0)	68 (67.3)	-	5.12	4	0.28
	NO FOOT	14 (14.0)	7 (7.0)	0 (0.0)	-	-	1 (1.0)	78 (78.0)	-			
V	DS FOOT	-	-	7 (6.9)	-	-	-	92 (91.1)	2 (2.0)	6.75	2	**0.03****
	NO FOOT	-	-	1 (1.0)	-	-	-	99 (99.0)	0 (0.0)			
VI	DS FOOT	-	-	26 (25.7)	-	-	-	74 (73.3)	1 (1.0)	1.39	2	0.50
	NO FOOT	-	-	30 (30.0)	-	-	-	70 (70.0)	0 (0.0)			
VII	DS FOOT	-	-	5 (5.0)	-	-	-	96 (95.0)	-	0.11	1	0.77
	NO FOOT	-	-	6 (6.0)	-	-	-	94 (94.0)	-			
VIII	DS FOOT	-	-	-	-	-	-	99 (98.0)	2 (2.0)	2.00	1	0.50
	NO FOOT	-	-	-	-	-	-	100 (100.0)	0 (0.0)			
IX	DS FOOT	-	-	-	-	-		90 (89.1)	11 (10.9)	0.04	1	1.00
	NO FOOT	-	-	-	-	-	--	90 (90.0)	10 (10.0)			
X	DS FOOT	3 (3.0)	-	-	4 (4.0)	-	-	81 (80.2)	13 (12.9)	7.86	3	0.05
	NO FOOT	0 (0.0)	-	-	0 (0.0)	-	-	90 (90.0)	10 (10.0)			
Big Toe	DS FOOT	-	-	-	66 (65.3)	13 (12.9)	22 (21.8)	-	-	13.25	2	**0.00****
	NO FOOT	-	-	-	65 (65.0)	28 (28.0)	7 (7.0)	-	-			

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant

Table 2a: Distribution of the right foot and test of association in males of Down's syndrome and normal subjects

Right Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
I	DS FOOT	12 (20.7)	1 (1.7)	1 (1.7)	-	-	8 (13.8)	35 (60.3)	1 (1.7)	64.766	6	**0.000****
	NO FOOT	3 (4.6)	-	9 (13.8)	1 (1.5)	-	47 (72.3)	5 (7.7)	-			
II	DS FOOT	-	11 (19.0)	-	-	-	1 (1.7)	46 (79.3)	-	48.126	3	**0.000****
	NO FOOT	34 (52.3)	-	-	-	-	1 (1.5)	30 (46.2)	-			
III	DS FOOT	23 (39.7)	3 (5.2)	-	-	-	2 (3.4)	30 (51.7)	-	17.491	3	**0.001****
	NO FOOT	28 (43.1)	5 (7.7)	-	-	-	17 (26.2)	15 (23.1)	-			
IV	DS FOOT	21 (36.2)	6 (10.3)	-	-	-	-	31 (53.4)	-	6.450	3	0.092
	NO FOOT	12 (18.5)	5 (7.7)	-	-	-	1 (1.5)	47 (72.3)	-			
V	DS FOOT	-	-	2 (3.4)	-	-	-	54 (93.1)	2 (3.4)	2.337	2	0.311
	NO FOOT	-	-	3 (4.7)	-	-	-	61 (95.3)	-			
VI	DS FOOT	-	-	18 (31.0)	-	-	-	39 (67.2)	1 (1.7)	1.514	2	0.469
	NO FOOT	-	-	24 (36.9)	-	-	-	41 (63.1)	-			
VII	DS FOOT	-	-	1 (1.7)	-	-	-	57 (98.3)	-	4.124	1	0.065
	NO FOOT	-	-	7 (10.8)	-	-	-	58 (89.2)	-			
VIII	DS FOOT	-	-	-	-	-	-	57 (98.3)	1 (1.7)	1.130	1	0.472
	NO FOOT	-	-	-	-	-	-	65 (100)	-			
IX	DS FOOT	-	-	-	-	-	-	51 (87.9)	7 (12.1)	0.051	1	1.000
	NO FOOT	-	-	-	-	-	-	58 (89.2)	7 (10.8)			
X	DS FOOT	4 (6.9)	-	-	1 (1.7)	-	-	44 (75.9)	9 (15.5)	6.354	3	0.096
	NO FOOT	-	-	-	-	-	-	57 (87.7)	8 (12.3)			
Big Toe	DS FOOT	-	-	-	36 (62.1)	8 (13.8)	14 (24.1)	-	-	10.659	2	**0.005****
	NO FOOT	-	-	-	41 (63.1)	20 (30.8)	4 (6.2)	-	-			

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant

Table 2b: Distribution of the left foot and test of association in males of Down's syndrome and normal subjects

Left Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
I	DS FOOT	12 (20.7)	-	-	-	-	8 (13.8)	36 (62.1)	2 (3.4)	65.213	4	**0.000****
	NO FOOT	3 (4.6)	-	8 (12.30	-	-	48 (73.8)	6 (9.2)	-			
II	DS FOOT	-	11 (19.0)	-	-	-	-	47 (81.0)	-	13.75	2	**0.001****
	NO FOOT	1 (1.5)	32 (49.2)	-	-	-	-	32 (49.2)	-			
III	DS FOOT	25 (43.1)	2 (3.4)	-	-	-	2 (3.4)	28 (48.3)	1 (1.7)	17.393	4	**0.002****
	NO FOOT	29 (44.6)	4 (6.2)	-	-	-	17 (26.2)	15 (23.1)	-			
IV	DS FOOT	12 (20.7)	8 (13.8)	1 (1.7)	-	-	-	37 (63.8)	-	3.773	4	0.438

Left Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
	NO FOOT	11 (16.9)	5 (7.7)	-	-	-	1 (1.5)	48 (73.8)	-			
V	DS FOOT	-	-	4 (6.9)	-	-	-	52 (89.7)	2 (3.4)	4.658	2	0.097
	NO FOOT	-	-	1 (1.5)	-	-	-	64 (98.5)	-			
VI	DS FOOT	-	-	15 (25.9)	-	-	-	42 (72.4)	1 (1.7)	2.293	2	0.318
	NO FOOT	-	-	23 (35.4)	-	-	-	42 (64.6)	-			
VII	DS FOOT	-	-	3 (5.2)	-	-	-	55 (94.8)	-	0.055	1	1.000
	NO FOOT	-	-	4 (6.2)	-	-	-	61 (93.8)	-			
VIII	DS FOOT	-	-	-	-	-	-	57 (98.3)	1 (1.7)	1.130	1	0.472
	NO FOOT	-	-	-	-	-	-	65 (100)	-			
IX	DS FOOT	-	-	-	-	-	-	53 (91.4)	5 (8.6)	0.161	1	0.768
	NO FOOT	-	-	-	-	-	-	58 (89.2)	7 (10.8)			
X	DS FOOT	3 (5.2)	-	-	3 (5.2)	-	-	45 (77.6)	7 (12.1)	7.266	3	0.064
	NO FOOT	-	-	-	-	-	-	58 (89.2)	7 (10.8)			
Big Toe	DS FOOT	-	-	-	34 (58.6)	8 (13.8)	16 (27.6)	-		10.084	2	**0.006****
	NO FOOT	-	-	-	42 (64.6)	18 (27.7)	5 (7.7)	-				

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant,

Table 3a: Distribution of the right foot and test of association in females of Down's syndrome and normal subjects

Right Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
I	DS FOOT	15 (34.9)	-	-	-	-	9 (20.9)	17 (39.5)	2 (4.7)	37.049	4	**0.000****
	NO FOOT	3 (8.6)	-	5 (14.3)	-	-	26 (74.3)	1 (2.9)	-			
II	DS FOOT	1 (2.3)	7 (16.3)	-	-	-	1 (2.3)	34 (79.1)	-	15.430	3	**0.001****
	NO FOOT	10 (28.6)	-	-	-	-	1 (2.9)	24 (68.6)	-			
III	DS FOOT	16 (37.2)	3 (7.0)	-	-	-	-	24 (55.8)	-	12.190	3	**0.007****
	NO FOOT	18 (51.4)	1 (2.9)	-	-	-	6 (17.1)	10 (28.6)	-			
IV	DS FOOT	15 (34.9)	-	-	-	-	-	28 (65.1)	-	13.278	2	**0.001****
	NO FOOT	2 (5.7)	4 (11.4)	-	-	-	-	29 (82.9)	-			
V	DS FOOT	-	-	1 (2.3)	-	-	-	41 (95.3)	1 (2.3)	1.671	2	0.434
	NO FOOT	-	-	-	-	-	-	35 (100)	-			
VI	DS FOOT	-	-	13 (30.2)	-	-	-	30 (69.8)	-	1.060	1	0.435
	NO FOOT	-	-	7 (20.0)	-	-	-	28 (80.0)	-			
VII	DS FOOT	-	-	2 (4.7)	-	-	-	41 (95.3)	-	0.045	1	1.000
	NO FOOT	-	-	2 (5.7)	-	-	-	33 (94.3)	-			
VIII	DS FOOT	-	-	-	-	-	-	42 (97.7)	1 (2.3)	0.825	1	1.000
	NO FOOT	-	-	-	-	-	-	35 (100)	-			
IX	DS FOOT	-	-	-	-	-	-	35 (81.4)	8 (18.6)	2.868	1	0.171
	NO FOOT	-	-	-	-	-	-	33 (94.3)	2 (5.7)			
X	DS FOOT	-	-	-	1 (2.3)	-	-	37 (86.0)	5 (11.6)	0.921	2	0.631
	NO FOOT	-	-	-	-	-	-	30 (85.7)	5 (14.3)			
Big Toe	DS FOOT	-	-	-	34 (79.1)	4 (9.3)	5 (11.6)	-	-	9.787	2	**0.007****
	NO FOOT	-	-	-	21 (60.0)	13 (37.1)	1 (2.9)	-	-			

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant

Table 3b: Distribution of the left foot and test of association in females of Down's syndrome and normal subjects

Left Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
I	DS FOOT	12 (27.9)	-	-	-	-	11 (25.6)	19 (44.2)	1 (2.3)	29.735	4	0.000**
	NO FOOT	3 (8.6)	-	4 (11.4)	-	-	26 (74.3)	2 (5.7)	-			
II	DS FOOT	1 (2.3)	6 (14.0)	-	-	-	-	36 (83.7)	-	5.573	3	0.134
	NO FOOT	-	11 (31.4)	-	-	-	1 (2.9)	23 (65.7)	-			
III	DS FOOT	16 (37.2)	3 (7.0)	-	-	-	1 (2.3)	23 (53.5)	-	9.584	3	0.022**
	NO FOOT	11 (31.4)	2 (5.7)	-	-	-	9 (25.7)	13 (37.1)	-			
IV	DS FOOT	11 (25.6)	1 (2.3)	-	-	-	-	31 (72.1)	-	4.144	2	0.126
	NO FOOT	3 (8.6)	2 (5.7)	-	-	-	-	30 (85.7)	-			
V	DS FOOT	-	-	3 (7.0)	-	-	-	40 (93.0)	-	2.540	1	0.248
	NO FOOT	-	-	0 (0.0)	-	-	-	35 (100.0)	-			
VI	DS FOOT	-	-	11 (25.6)	-	-	-	32 (74.4)	-	0.339	1	0.600
	NO FOOT	-	-	7 (20.0)	-	-	-	28 (80.0)	-			
VII	DS FOOT	-	-	2 (4.7)	-	-	-	41 (95.3)	-	0.045	1	1.000
	NO FOOT	-	-	2 (5.7)	-	-	-	33 (94.3)	-			
VIII	DS FOOT	-	-	-	-	-	-	42 (97.7)	1 (2.3)	0.825	1	1.000
	NO FOOT	-	-	-	-	-	-	35 (100)	-			
IX	DS FOOT	-	-	-	-	-	-	37 (86.0)	6 (14.0)	0.548	1	0.504
	NO FOOT	-	-	-	-	-	-	32 (91.4)	3 (8.6)			
X	DS FOOT	-	-	-	1 (2.3)	-	-	36 (83.7)	6 (14.0)	1.430	2	0.489
	NO FOOT	-	-	-	0	-	-	32 (91.4)	3 (8.6)			

Left Foot	Group	Ld (%)	Lp (%)	Lt (%)	Lf (%)	A (%)	W (%)	O (%)	V (%)	Chi-square analysis		
										X2	df	P-value
Big Toe	DS FOOT	-	-	-	32 (74.4)	5 (11.6)	6 (14.0)	-	-	4.365	2	0.113
	NO FOOT	-	-	-	23 (65.7)	10 (28.6)	2 (5.7)	-	-			

Note: DS- Down's syndrome, NO-normal, Ld- distal loop, Lp- proximal loop, Lt- tibial loop, Lf- fibular loop, A- Arch, W- whorl, O- Open field, V- vestiges, df-degree of freedom, **-significant

DISCUSSION

The evaluation of the sole has been seen to be a difficult one because of the nature of the foot, as a result the present study only examined the sole and the big toe since the smaller toes were not easy to take print.

The study revealed that Down's syndrome subjects have more of distal loop, proximal loop and open field while the control subjects have higher frequency of whorls. There is a significant difference across the patterns in zones I to IV in the present study on the right hand while on the left the difference was observed in zones I to III and V on both sexes. The Federal Bureau of Investigation system (FBI's) is particularly interested in the ball area of the foot (zone I) which is directly below the large toe because it holds unique identifiable friction ridge patterns similar to fingerprints (Hutchins 2002). The area has three patterns, arch/open field, loop and whorl. In the present study the frequency of distal loop and proximal loop were higher in zone I and zone II of Down's syndrome respectively when compared to control subjects. This is in contrast to the study of Oghenemavwe & Tagar (2017) who reported increase frequency of distal loop (upright loop) and proximal loop (inverted loop) for zone I and II in control subjects between Down's syndrome and control subjects. Osaat *et al.* (2023) observed increased frequency of proximal loop on zone II between autistic and control subjects. For Down's syndrome subjects there was a decrease frequency of whorl from zone I to zone IV on the right hand of both sexes. This is in line with the observations of Oghenemavwe & Tagar (2017) who reported decrease frequency of whorl for Down syndrome and increase frequency for healthy subjects. However, Igbigbi *et al.,* (2001) reported whorls on zone I for hypertensive patients, Diabetes with hypertension had whorls on zones I, III & IV, while diabetes alone had whorls on zones I, II, & III. Osaat *et al.,* (2023) also observed higher frequency of whorls for autistic subjects in zones I and III. For healthy subjects the frequency of whorls was higher when compared to Down's syndrome subjects across the zones I to IV. Igbigbi & Didia (1999) worked on the Urhobos of Nigeria and got similar findings. However, Igbigbi & Msamati (2001) observed whorl on zones I, III & IV of Zimbabwean subjects indicating racial and ethnic differences.

In the present study open field was seen to be strikingly very high in zones I to III and VII of Down's syndrome when compared to control subjects and difference was significant. This is also in consonance with the study of Hsu *et al.,* (1971) who reported over 90% of plantar hallucal patterns of patients in contrast to the control. The high percentage of open field in the hallucal area could serve as an indication of Down's syndrome in Nigeria – a dermatoglyphic feature. Again Bryant *et al.,* (1970) observed the presence of hallucal arch tibial pattern with in Suggested that they had diagnostic value in differentiating Down's syndrome patients from controls. This means the study of Bryant *et al.,* (1970) on Chinese was similar to the present study on Nigerians.

The sole is classified into distal (I – V) and proximal zones (VI – X). Distal loop and proximal loop were present in some distal and proximal zones. Abue & Didia (2013) reported more loops on the proximal than the distal surface. The proximal zones (VI – X) were not statistically significant and are present with mostly untrue patterns (open field and vestiges), at times tibial loop which are especially seen in zone VI-VII. In zone VI, tibial loop was observed to be more in Down's syndrome followed by controls. From zones VIII – X, there were the presence of more open fields and vestiges in both Down's syndrome and control groups. This was in line with the study of Siemens (1954) who observed more than ninety nine percent of open fields and few vestiges on the soles of Jewish and non-Jewish people.

The distribution of patterns between Down's syndrome and normal subjects was significant in zones I to IV (right foot) and I to III and V (left foot) of both sexes, for males subjects, it was significant in zones I to III (right foot) and I to IV (left foot), while for females it was significant in zones I to IV (right foot) and I and III (left foot). In male Down's syndrome subjects, distal loop was observed in zone I than in control. Proximal loop was observed in zone I and II. This was also in line with Rohini & Mohan (2015) who observed significantly higher distal loop in the right foot of male subjects than female subjects. Sexual dimorphism was observed. Open field was observed in zone I to III. While the frequency of whorl was significantly reduced for Down's syndrome and increased in control subjects, this is similar to Oghenemavwe & Tagar (2017). Whorl was observed in control than Down's syndrome. Same result was observed for female subjects. Osaat *et al*. (2023) reported significant increase in the distal and proximal loops on zones II and III.

Down's syndrome subjects showed strong statistically significant difference in the distribution of big toe patterns when compared to control subjects on both feet, in males and in females. Down's syndrome subjects have increased percentage of whorl on the big toe than control subjects. The results show a strong genetic basis of Down's syndrome when compared to control subjects. However, according to twins studies the

feet patterns are subject to less hereditary control than the ridge patterns of the hands, (Villar & Epstein, 2005; Ahmed-Popova *et al.,* 2014).

CONCLUSION

In conclusion the study had been able to highlight some differences between Down's syndrome and healthy subjects in Nigeria. As observed from the study Down's syndrome had increased frequency of distal and proximal loop on zones I and II respectively, increased frequency of open field and vestiges on zones I to III. On the other hand there was significant increase in whorl for control subjects when compared to Down's syndrome subjects. There was significant difference between Down's syndrome subjects and control subjects in Nigeria across zones I to V. The difference across the pattern in the big toe between Down's syndrome and control subjects was significant with Down's syndrome having more of whorl than control subjects. This study recommends the sole and big toe dermatoglyphics as a supportive Method in the diagnosis of Down's syndrome in Nigeria when other methods have failed or is in doubt.

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