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Dermatoglyphics in Down's syndrome

Osaat, Roseline Sunday[1*]

[1]Department of Anatomy, Faculty of Basic Medical Sciences, Federal University Otuoke, Bayelsa State, Nigeria. E-mail: osaatrs@fuotuoke.edu.ng

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Abstract

This study aimed at determining the dermatoglyphic patterns of Down's syndrome subjects in Nigeria. A digital scanning method was used to select subjects and a total of 101 Down's syndrome subjects (58 males and 43 females) and 100 control subjects (65 males and 35 females) were used for the study. The subjects were conveniently selected from various special schools in Nigeria. The data were tested using Chi-square and Mann-Whitney U test. A significantly increased ulnar loop was observed for Down's syndrome. The distribution of fingerprint patterns and finger ridge counts were observed to be significantly different between Down's syndrome and control subjects and they were particularly observed in the index and middle fingers (both right and left hands) for both sexes, male subjects ($p<0.05$). As such, the total finger ridge count was higher in Down's syndrome as compared to control subjects and it was particularly observed on the right hands of both sexes and male subjects ($p<0.05$). The females showed no significant difference. In conclusion, the study revealed significant difference between Down's syndrome and control subjects deducing that dermatoglyphics could be correlated to Down's syndrome and could be used for its early diagnosis to aid early intervention.

Keywords: *Dermatoglyphics, Down's syndrome, Control, Early intervention, Nigeria*

1. Introduction

Dermatoglyphics as the scientific study of epidermal ridges of the skin (both fingerprints and footprints) (Moore and Persaud, 2003), is believed to provide understanding and solution to questions in some areas of life especially in medicine, genetics and evolution (Pratibha *et al.*, 2011; Oladipo *et al.*, 2013). This science of dermatoglyphics is seen to be important because it is based on the fact that ridges are different for different fingers and no two persons show exactly similar fingerprint patterns, also, the ridges are permanent throughout the life of a person (Singh *et al.*, 2016a; Sandeep *et al.*, 2012; Jeewandeep and Arvinder, 2013). Again the development of the brain and the skin at about the same period could be the cause of ridge pattern affected by certain abnormalities of early development. As a result of this effect, dermatoglyphics is correlated with some genetic abnormalities such as mental illnesses and chromosomal disorders such as down syndrome, autism, diabetes, schizophrenia, etc. (Walker, 1977; Lainhart *et al.*, 1997; Bulagouda *et al.*, 2013; Singh *et al.*, 2016a, b).

* *Corresponding author: Osaat, Roseline Sunday, Department of Anatomy, Faculty of Basic Medical Sciences, Federal University Otuoke, Bayelsa State, Nigeria. E-mail: osaatrs@fuotuoke.edu.ng*

Based on these, dermatoglyphics is applied and is used in various fields (Tarca, 2008; Oladipo *et al.*, 2010; Pratibha *et al.*, 2011) such as identification of individual. This application started with William Herschel in 1858 that identified his contractors from their finger prints and hand prints (Cummins and Midlo, 1943). Earlier before now, dermatoglyphics was used to understand individual potentiality(ies) and talents (Campbell, 1998; Sharma *et al.*, 2018). It was believed that everybody inherits some level of innate intelligence from their parents (The Secret of Your Child Fingerprint, 2011). The palmistry uses it for fortune telling as well as prophecy (Campbell, 1998).Today, dermatoglyphics has so much application than what was mentioned above. Its applications can be found in psychiatry, twin diagnosis, forensic and anthropology studies, maternal disputed paternity, as well as medical/disease diagnosis (Schaumann and Alter, 1976). Studies have shown that, dermatoglyphics plays a crucial role in the early diagnosis of genetic diseases (Verbov, 1970; Oladipo *et al.*, 2009; Mollic and Habib, 2011; Reed *et al.*, 1978; Osaat *et al.*, 2022; Osaat *et al.*, 2019)

Even in the phase of DNA testing, fingerprint or dermatoglyphics is still significantly important especially for twin diagnosis. It has been reported that no two monozygotic twins have the same fingerprint pattern and ridges (Reed *et al.*, 1975; Reed *et al.*, 1978). Fingerprint plays its outstanding roles of individuality and uniqueness for proper identification. No wonder dermatoglyphics was referred to as "DNA reflected in the appearance of our body" (The Secret of Your Child's Fingerprint, 2011). Today medical dermatoglyphics applies dermatoglyphics in the diagnosis of so many diseases with 80% to 90% accuracy (Schaumann and Alter, 1976). Infact the diagnosis of these disorders can now be done on the basis of dermatoglyphics analysis alone (Johnny, 2018).

Down's Syndrome (DS) is a chromosomal condition caused by the presence of all or part of a third copy of chromosome twenty one (21). It is also called trisomy 21 (Gordon, 2010; Butler and 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 incidence of Down's syndrome in Nigeria as reported by Adeyokunnu (1982) is one in eight hundred and sixty five (865) livebirths in Nigerian hospital.

It is evident that some researchers have reported certain level of correlations between dermatoglyphics and some disorders that have genetic origin such as autism (Milicic *et al.*, 2003; Stosljevic and Adamovic, 2013; Oladipo *et al.*, 2013; Osaat *et al.*, 2019) and Down's syndrome (Boroffice, 1978; Arrieta *et al.*, 1990; Tarca and Barabolski, 2003; Sharma *et al.*, 2012; Stosljevic and Adamovic, 2013), mental retardation (Stevenson *et al.*, 1997), breast cancer (Raizada *et al.*, 2013), Idiopathic Dilated Cardiomyopathy (Oladipo *et al.*, 2007), Obesity (Oladipo *et al.*, 2010), Schizophrenia (Ozyurt *et al.*, 2010), Sickle Cell Anemia (Ramesh *et al.*, 2012), Epilepsy (Aminu *et al.*,2014), and Diabetes Mellitus (Shield *et al.*, 1995; Oladipo and Ogunnowo, 2004; Oladipo *et al.*, 2012; Pushpa *et al.*, 2013), due to the fact that genetic and uterine environmental events influence dermal pattern formation and so genetic anomalies in the process leave markers in the ridge pattern.

According to Sharma *et al.* (2012) found out that dermatoglyphics may be used as diagnostic tool for predicting the possibilities of development of Down's syndrome at later date. Barbosa *et al.* (2009) also found out that Down's syndrome can be determined using dermatoglyphics.

Boroffice (1978) conducted a study on the dermatoglyphics and found out that Down's syndrome is highly dermatoglyphic specific.

Obviously, dermatoglyphics have been extensively studied in Nigeria and other countries especially on other genetic disorders, however information on dermatoglyphic patterns of Down syndrome are relatively scarce in Nigeria. Therefore, this study aimed at determining the dermatoglyphics (fingerprint) patterns of Down syndrome in Nigeria.

2. Materials and Methods

A descriptive sample survey method was used to investigate the fingerprints patterns of Down's syndrome. The research was carried out in some selected cities in Nigeria such as Lagos, Abuja and Port Harcourt. This study comprised both male and female Down's syndrome subjects in Nigeria, between 5 to 35 years of age. Though no documented statistical record on the population of Down's syndrome subjects in Nigeria, Adeyokunnu (1982) reported the prevalence rate of 1 in 865 live births. Based on this prevalence, the sample

size was determined using Cochran formula (Daniel, 1999) and the minimum sample size of 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. The subjects 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 and must be within the age range for the study were selected for the study.

The study adopted the method according to Oghenemavwe and Osaat (2015). The dermatoglyphic patterns were collected and determined using the scanning method which involves a High-resolution digital scanner-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.

The subjects' fingers and palms were thoroughly washed with water and soap and dried with clean towel to remove dirt. The subject was asked or assisted to place the washed palms on the scanner and accordingly the palms were scanned. The thumb prints were taken separately from the other fingers and palm because of its position to obtain maximum clarity. 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. Ridge counting was done using AUTOCAD Program (version 2010), it was also used to count ridges with limited errors. The Finger Print Patterns analyzed include: Arch (A), Ulnar Loop (UL), Radial Loop (RL) and Whorl (W). Finger Ridge Count (FRC) and Total Finger Ridge Count (TFRC) were analyzed for individual fingers on both right and left hands. TFRC includes the sum of the ten finger ridge counts. This counting was done along the straight line connecting one tri-radial point (tri-radial point is formed by the confluence of the three ridge system) to the point of core.

The data obtained from this study were subjected to test using Statistical Package for Social Science ((SPSS) IBM ® Version 23 New York). For clarity, tables were used to present results. Mann-Whitney U test analysis was used to compare all the quantitative data such as Finger Ridge Counts (FRC), while Chi-square was used for analysis on percentage frequencies of finger patterns. All statistical testing was done at 95% confidence level with p-value less than 0.05 ($p<0.05$) taken to be significant.

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.

3. Results

Tables 1a and 1b showed the distribution of right and left finger print patterns and test of association respectively, in both sexes of Down's syndrome and normal subjects. A significant difference in the index, middle and little fingers of the right hand of Down's syndrome and normal subjects ($p<0.05$) was observed. The thumb and ring fingers were not statistically significant though they have variable percentage of patterns in those fingers. Table 1c summarized the differences in the pattern of Down's syndrome and normal subjects as tested using chi square. In both right and left hands there were significant differences amongst the patterns of Down's syndrome and normal subjects ($p<0.05$).

In Tables 2a and 2b, significant difference was observed in males of Down's syndrome and normal subjects in both the index, middle and little fingers of the right and left hands ($p<0.05$). Other fingers were not significant as $p>0.05$. In Table 2c, the result showed that there was statistically significant difference in the fingerprint patterns of Down's syndrome and normal male subjects on both right and left hands ($p<0.05$).

However, in Table 3a the female showed significant differences only in the middle fingers on the right hand of Down's syndrome and normal subjects ($p<0.05$). The other fingers were not statistically significant though they were variable percentage of patterns in those fingers. In Table 3b, on the left hand, significant difference was demonstrated in the index and middle fingers of Down's syndrome and normal subjects ($p<0.05$). The thumb, ring and little fingers were not statistically significant as well. Table 3c summarized the differences in the pattern of Down's syndrome and normal subject as tested using chi square. Like the male subjects, there

Table 1a: Distribution of the right finger print pattern and test of association of both sexes

Right finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	16 (15.8)	-	47 (46.5)	38 (37.6)	4.20	2	0.12
	NO subjects	12 (12.0)	-	36 (36.0)	52 (52.0)			
Index	DS subjects	6 (5.9)	1 (1.0)	84 (83.2)	10 (9.9)	40.35	3	0.00**
	NO subjects	15 (15.0)	2 (2.0)	40 (40.0)	43 (43.0)			
Middle	DS subjects	-	-	93 (92.1)	8 (7.9)	18.72	3	0.00**
	NO subjects	10 (10.0)	1 (1.0)	70 (70.0)	19 (19.0)			
Ring	DS subjects	1 (1.0)	-	55 (54.5)	45 (44.6)	1.38	3	0.71
	NO subjects	2 (2.0)	1 (1.0)	54 (54.0)	43 (43.0)			
Little	DS subjects	-	-	78 (77.2)	23 (22.8)	13.96	2	0.00**
	NO subjects	3 (3.0)	-	91 (91.0)	6 (6.0)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

Table 1b: Distribution of the left finger print pattern and test of association of both sexes

Left finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	26 (25.7)	-	44 (43.6)	31 (30.7)	5.25	2	0.07
	NO subjects	14 (14.0)	-	44 (44.0)	42 (42.0)			
Index	DS subjects	2 (2.0)	1 (1.0)	83 (82.2)	15 (14.9)	30.66	3	0.00**
	NO subjects	16 (16.0)	4 (4.0)	46 (46.0)	34 (34.0)			
Middle	DS subjects	2 (2.0)	-	90 (89.1)	9 (8.9)	16.45	3	0.00**
	NO subjects	16 (16.0)	1 (1.0)	68 (68.0)	15 (15.0)			
Ring	DS subjects	2 (2.0)	2 (2.0)	57 (56.4)	40 (39.6)	0.54	3	0.91
	NO subjects	3 (3.0)	1 (1.0)	57 (57.0)	39 (39.0)			
Little	DS subjects	-	-	84 (83.2)	17 (16.8)	11.50	2	0.00**
	NO subjects	3 (3.0)	-	93 (93.0)	4 (4.0)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

Table 1c: Chi-square test comparing the dermatoglyphic patterns of Down's syndrome and normal subjects of both sexes

Group	Right				Chi-square analysis			Left				Chi-square analysis		
	A	RL	UL	W	df	X^2	*P*-value	A	RL	UL	W	df	X^2	*P*-value
DS subjects	23	1	357	124	3	14.17	0.00**	32	3	358	112	3	11.46	0.01**
NO subjects	42	4	302	149				52	6	308	134			

Note: A - Arch; RL - Radial loop; UL - Ulnar loop; W - Whorl; ** - significant; DS - Down's syndrome; NO - Normal; df - degree of freedom.

were significant differences amongst the patterns of Down's syndrome and normal subjects ($p<0.05$) in both right and left hands of female subjects.

As shown in Tables 4a and 4b, Mann-Whitney U test was used to test for differences between finger ridge count of Down's syndrome subjects and normal subjects on the right and left hands respectively of both sexes.

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

Right finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	11 (19.0)		25 (43.1)	22 (37.9)	4.08	2	0.13
	Normal subjects	7 (10.8)		22 (33.8)	36 (55.4)			
Index	DS subjects	6 (10.3)		45 (77.6)	7 (12.1)	22.14	3	0.00**
	Normal subjects	11 (16.9)	2 (3.1)	24 (36.9)	28 (43.1)			
Middle	DS subjects			52 (89.7)	6 (10.3)	12.50	3	0.01**
	Normal subjects	9 (13.8)	1 (1.5)	43 (66.2)	12 (18.5)			
Ring	DS subjects			31 (53.4)	27 (46.6)	3.22	3	0.36
	Normal subjects	2 (3.1)	1 (1.5)	37 (56.9)	25 (38.5)			
Little	DS subjects			41 (70.0)	17 (29.3)	13.613	2	0.00**
	Normal subjects	3 (4.6)		58 (89.2)	4 (6.2)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

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

Left finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	17 (29.3)		23 (39.7)	18 (31.0)	5.58	2	0.06
	Normal subjects	8 (12.3)		30 (46.2)	27 (41.5)			
Index	DS subjects	1 (1.7)		49 (84.5)	8 (13.8)	24.84	3	0.00**
	Normal subjects	13 (20.0)	4 (6.2)	28 (43.1)	20 (30.8)			
Middle	DS subjects	2 (3.4)		51 (87.9)	5 (8.6)	8.12	3	0.04**
	Normal subjects	12 (18.5)	1 (1.5)	46 (70.8)	6 (9.2)			
Ring	DS subjects			33 (56.9)	25 (43.1)	5.52	3	0.14
	Normal subjects	3 (4.6)	1 (1.5)	42 (64.6)	19 (29.2)			
Little	DS subjects			47 (81.0)	11 (19.0)	8.56	2	0.01**
	Normal subjects	3 (4.6)		59 (90.8)	3 (4.6)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

Table 2c: Chi-square test comparing the finger patterns of male Down's syndrome and normal subjects

Group	Right				Chi-square analysis			Left				Chi-square analysis		
	A	RL	UL	W	df	X^2	P-value	A	RL	UL	W	df	X^2	P-value
DS subjects	17	4	194	79	3	11.37	0.010**	20	-	203	67	3	10.62	0.014**
NO subjects	151	-	194	79				39	6	205	75			

Note: A - Arch; RL - Radial loop; UL - Ulnar loop; W - Whorl; ** - significant; DS - Down's syndrome; NO - Normal; df - degree of freedom.

In Table 4a, the result on the right hand showed that the index, middle and little fingers of Down's syndrome subjects were significantly increased from those of normal subjects ($p<0.05$), while in Table 4b the result on the

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

Right finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	5 (11.6)		22 (51.2)	16 (37.2)	0.97	2	0.62
	NO subjects	5 (14.3)		14 (40.0)	16 (45.7)			
Index	DS Subjects		1 (2.3)	39 (90.7)	3 (7.0)	22.03	3	0.00**
	NO subjects	4 (11.4)		16 (45.7)	15 (42.9)			
Middle	DS Subjects			41 (95.3)	2 (4.7)	5.90	2	0.05
	NO subjects	1 (2.9)		27 (77.1)	7 (20.0)			
Ring	DS subjects	1 (2.3)		24 (55.8)	18 (41.9)	1.39	2	0.50
	NO subjects			17 (48.6)	18 (51.4)			
Little	DS subjects			37 (86.0)	6 (14.0)	1.42	1	0.28
	NO subjects			33 (94.3)	2 (5.7)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

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

Left finger	Group	Arch (%)	Radial loop (%)	Ulnar loop (%)	Whorl (%)	Chi-square analysis		
						X^2	df	P-value
Thumb	DS subjects	9 (20.9)		21 (48.8)	13 (30.2)	1.34	2	0.51
	NO subjects	6 (17.1)		14 (40.0)	15 (42.9)			
Index	DS subjects	1 (2.3)	1 (2.3)	34 (79.1)	7 (16.3)	8.53	3	0.04**
	NO subjects	3 (8.6)		18 (51.4)	14 (40.0)			
Middle	DS subjects			39 (90.7)	4 (9.3)	9.95	2	0.01**
	NO subjects	4 (11.4)		22 (62.9)	9 (25.7)			
Ring	DS subjects	2 (4.7)	2 (4.7)	24 (55.8)	15 (34.9)	6.03	3	0.11
	NO subjects			15 (42.9)	20 (57.1)			
Little	DS subjects			37 (86.0)	6 (14.0)	2.91	1	0.12
	NO subjects			34 (97.1)	1 (2.9)			

Note: DS - Down's syndrome; NO - Normal; df - degree of freedom.

Table 3c: Chi-square test comparing the finger patterns of female Down's syndrome and normal subjects

Group	Right				Chi-square analysis			Left				Chi-square analysis		
	A	RL	UL	W	df	X^2	P-value	A	RL	UL	W	df	X^2	P-value
DS subjects	6	1	163	45	3	11.27	0.010**	12	3	155	45	3	11.42	0.010**
NO subjects	10	-	107	58				13	-	103	59			

Note: A - Arch; RL - Radial loop; UL - Ulnar loop; W - Whorl; ** - significant; DS - Down's syndrome; NO - Normal; df - degree of freedom.

left hand showed only the index and middle fingers were significant ($p<0.05$). In Tables 5a and 5b, the results on the right and left hands respectively of male Down's syndrome and normal subjects showed that the index

Table 4a: Mann-Whitney U test comparing the right finger ridge count of Down's syndrome and normal Subjects of both sexes

Right finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS subjects	101	103.77	10481.00	4770.00	9820.00	-0.68	0.50
	NO subjects	100	98.20	9820.00				
Index	DS subjects	101	117.78	11896.00	3355.00	8405.00	-4.12	0.00**
	NO subjects	100	84.05	8405.00				
Middle	DS subjects	101	122.33	12355.50	2895.50	7945.50	-5.24	0.00**
	NO subjects	100	79.46	7945.50				
Ring	DS subjects	101	103.34	10437.50	4813.50	9863.50	-0.57	0.57
	NO subjects	100	98.64	9863.50				
Little	DS subjects	101	109.65	11075.00	4176.00	9226.00	-2.13	0.03**
	NO subjects	100	92.26	9226.00				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 4b: Mann-Whitney U test comparing the left finger ridge count of Down's syndrome and normal Subjects of both sexes

Left finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS subjects	101	100.74	10175.00	5024.00	10175.00	-0.06	0.95
	NO subjects	100	101.26	10126.00				
Index	DS subjects	101	116.74	11791.00	3460.00	8510.00	-3.87	0.00**
	NO subjects	100	85.10	8510.00				
Middle	DS subjects	101	118.23	11941.00	3310.00	8360.00	-4.23	0.00**
	NO subjects	100	83.60	8360.00				
Ring	DS subjects	101	95.73	9668.50	4517.50	9668.50	-1.29	0.20
	NO subjects	100	106.33	10632.50				
Little	DS subjects	101	100.40	10140.50	4989.50	10140.50	-0.15	0.88
	NO subjects	100	101.61	10160.50				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 4c: Total Finger Ridge Count (TFRC) of Down's syndrome and normal subjects compared using Mann-Whitney U test of both sexes

Total finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Right total RC	DS subjects	101	112.45	11357.00	3894.00	8944.00	-2.80	0.01**
	NO subjects	100	89.44	8944.00				
Left total RC	DS subjects	101	107.33	10840.50	4410.50	9460.50	-1.55	0.12
	NO subjects	100	94.61	9460.50				

Note: ** - Significant; DS - Down's syndrome; RC - Ridge count; z - z score.

and middle fingers were significant different in their ridge counts ($p<0.05$). In Table 6a only the little finger was significantly different in their ridge count between female Down's syndrome and female normal subjects

Table 5a: Distribution of the right finger ridge count and test of association in males of Down's syndrome and normal subjects

Right finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS subjects	101	103.77	10481.00	4770.00	9820.00	-0.68	0.50
	NO subjects	100	98.20	9820.00				
Index	DS subjects	101	117.78	11896.00	3355.00	8405.00	-4.12	0.00**
	NO subjects	100	84.05	8405.00				
Middle	DS subjects	101	122.33	12355.50	2895.50	7945.50	-5.24	0.00**
	NO subjects	100	79.46	7945.50				
Ring	DS subjects	101	103.34	10437.50	4813.50	9863.50	-0.57	0.57
	NO subjects	100	98.64	9863.50				
Little	DS subjects	101	109.65	11075.00	4176.00	9226.00	-2.13	0.03**
	NO subjects	100	92.26	9226.00				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 5b: Distribution of the left finger ridge count and test of association in males of Down's syndrome and normal subjects

Right finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS finger	58	64.37	3733.50	1747.50	3892.50	-0.70	0.48
	NO finger	65	59.88	3892.50				
Index	DS finger	58	75.08	4354.50	1126.50	3271.50	-3.86	0.00**
	NO finger	65	50.33	3271.50				
Middle	DS finger	58	78.80	4570.50	910.50	3055.50	-4.95	0.00**
	NO finger	65	47.01	3055.50				
Ring	DS finger	58	66.02	3829.00	1652.00	3797.00	-1.18	0.24
	NO finger	65	58.42	3797.00				
Little	DS finger	58	65.28	3786.00	1695.00	3840.00	-0.97	0.33
	NO finger	65	59.08	3840.00				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 5c: Male Total Finger Ridge Count (TFRC) of Down's syndrome and Normal subjects compared using Mann-Whitney U test

Total finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Right total RC	DS subjects	58	71.14	4126.00	1355.00	3500.00	-2.69	0.01**
	NO subjects	65	53.85	3500.00				
Left total RC	DS subjects	58	66.06	3831.50	1649.50	3794.50	-1.19	0.23
	NO subjects	65	58.38	3794.50				

Note: ** - Significant; DS - Down's syndrome; RC - Ridge count; z - z score.

on the right, while in Table 6b, on the left hand the middle finger of female Down's syndrome and normal subjects showed significant difference in their ridge counts ($p<0.05$).

Table 6a: Distribution of the right Finger Ridge Count (FRC) and test of association in females of Down's syndrome and normal subjects

Right finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS finger	43	40.87	1757.50	693.50	1323.50	-0.59	0.55
	NO finger	35	37.81	1323.50				
Index	DS finger	43	44.00	1892.00	559.00	1189.00	-1.95	0.05
	NO finger	35	33.97	1189.00				
Middle	DS finger	43	43.74	1881.00	570.00	1200.00	-1.85	0.06
	NO finger	35	34.29	1200.00				
Ring	DS finger	43	38.05	1636.00	690.00	1636.00	-0.63	0.53
	NO finger	35	41.29	1445.00				
Little	DS finger	43	45.28	1947.00	504.00	1134.00	-2.50	0.01**
	NO finger	35	32.40	1134.00				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 6b: Distribution of the left Finger Ridge Count (FRC) and test of association in females of Down's syndrome and normal subjects

Left finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Thumb	DS finger	43	38.02	1635.00	689.00	1635.00	-0.64	0.52
	NO finger	35	41.31	1446.00				
Index	DS finger	43	43.87	1886.50	564.50	1194.50	-1.89	0.06
	NO finger	35	34.13	1194.50				
Middle	DS finger	43	45.36	1950.50	500.50	1130.50	-2.54	0.01**
	NO finger	35	32.30	1130.50				
Ring	DS finger	43	39.60	1703.00	748.00	1378.00	-0.05	0.96
	NO finger	35	39.37	1378.00				
Little	DS finger	43	41.52	1785.50	665.50	1295.50	-0.88	0.38
	NO finger	35	37.01	1295.50				

Note: ** - Significant; DS - Down's syndrome; NO - Normal; z - z score.

Table 6c: Female Total Finger Ridge Count (TFRC) of Down's syndrome and Normal subjects compared using Mann-Whitney U test

Total finger ridge count	Group	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
Right total RC	DS subjects	43	42.17	1813.50	637.50	1267.50	-1.16	0.25
	NO subjects	35	36.21	1267.50				
Left total RC	DS subjects	43	41.78	1796.50	654.50	1284.50	-0.98	0.32
	NO subjects	35	36.70	1284.50				

Note: ** - Significant; DS - Down's syndrome; RC - Ridge count; z - z score.

In Table 4c, the TFRC result revealed a higher TFRC for Down's syndrome than normal subjects on the both hands though significant on the right hand. In Table 5c, the male Down's syndrome subjects have significantly

higher TFRC on the right hand than the male normal subjects ($p<0.05$). In Table 6c the female Down's syndrome subjects and normal subjects showed no statistically significant different on both hands though Down's syndrome has a higher TFRC than normal subjects ($p>0.05$).

4. Discussion

From the result of the study, Down's syndrome had higher percentage of ulnar loop but least percentages of arches and whorls than control subjects on both hands for both sexes, a dermatoglyphic feature which means that, low count of arches and higher count of ulnar loop is associated with Down's syndrome. It suggests genetics in the etiology of Down's syndrome. According to Babler (1991) the type of ridge pattern formed is associated with the timing of primary ridge formation. While early ridge formation was correlated with a whorl pattern, intermediate ridge formation was correlated with a loop and late ridge formation was correlated with an arch pattern. The female subjects have more arches and lesser whorls than their male counterparts. This may suggest sexual dimorphism. Verbov (1970) reported the same finding.

Down's syndrome subjects have decreased percentage of radial loop and it was seen mostly on the right index and left ring fingers. Bryant *et al.* (1970), Plato *et al.* (1973) and Fogle (1990) have similar findings. The frequency of radial loop was more in female than the male counterparts. This suggests that females may be more influenced by genetic factors than environmental factors.

Down's syndrome recorded the least percentage frequency of Whorl pattern which was in line with the study of Bryant *et al.* (1970). This result suggests the association of digital whorl pattern to normal subjects. As said earlier, whorl pattern was associated with early ridge formation (Babler, 1991) and suggests the least influenced by genetic factors. However, a genetic theory postulated by Slatis *et al.* (1976) proposed a genetic theory that ulnar loop is the basic fingerprint pattern found in all the fingers and that other patterns are formed with the activity of various genes acting on the pattern sequence causing deviation from the original pattern.

Again the present study observed an increased percentage of ulnar loops on the hands of Down's syndrome subjects. Infact Down's syndrome was seen to have the highest percentage of ulnar loop than the control. This finding was in line with previous authors (Bryant *et al.*, 1970; Boroffice, 1978; Rajangam *et al.*, 1995) who reported high frequency of ulnar loop on the fingers of Down's syndrome. Ulnar loop was seen on all fingers particularly little finger bilaterally (Bryant *et al.*, 1970; Tarca and Barabolski, 2003). The male Down's syndrome subjects have higher percentage of ulnar loop than female subjects (Barbosa *et al.*, 2009). A study on mentally retarded subjects also recorded strikingly high percentage of ulnar loop as compared with controls (Kiran *et al.*, 2010). The close resemblance could be because individual with Down's syndrome expressed very high level of mental retardation (Villar and Epstein, 2005). This again could serve as a diagnostic/screening tool for Down's syndrome and mentally retarded individuals meaning that though the ulnar loop pattern is the basic fingerprint (Slatis *et al.*, 1976) or the intermediate ridge formation (Babler, 1991), the extreme of it could be abnormal as seen in both Down syndrome subjects and mentally retarded individuals. The predominance of ulnar loop on the hands of Down's syndrome as compared with the control could serve as a dermatoglyphic features for its diagnosis.

The distribution of finger patterns between Down's syndrome and normal subjects on both sexes was significant in index, middle and little fingers for both hands $p<0.05$. The distribution of finger pattern between the male Down's syndrome and male control subjects was significant in the index, middle and little fingers on both hands, while the female subjects have significant distribution on the index finger alone (right hand) and index and middle fingers (left hand). Summarily, chi-square test showed statistically significant difference between Down's syndrome and control on both right and left finger patterns distribution on both sexes, male and female subjects. It can be deduced from the present study that amongst all fingers, the index finger of Down syndrome subjects is of great importance as it could give insight to finger that deviation from normal is mostly seen, seeing that, the distribution of pattern in index finger is significant for both sexes, for male, and for females subjects as against controls on both hands as seen in the result.

The genetics of finger ridge count and total ridge counts have revealed that there are considerable variations among individuals who are not related, however, statistically positive correlation is observed among relatives (Fogle, 1990). This is as a result of the degree of shared genetic heritage. Traits like TRC have a range of

phenotypic expression and are called quantitative traits. They are capable of letting known the genotype of an individual (Fogle, 1990). Ridge count distribution is a function of the frequency of the pattern types that occur on each of the ten fingers (Holt, 1968). From the present study the finger ridge count of Down's syndrome and controls of both sexes was observed to be significant in the index, middle and little fingers on the right hand. On the left hand only the index and middle fingers were statistically significantly different from each other. This appears to result from the high percentage frequencies of ulnar loop seen in the index, middle and little fingers of Down's syndrome when compared to the normal subjects. As such the Total Finger Ridge Count (TFRC) on the right hand was significantly increased in Down's syndrome when compared with controls while the left hand, statistically insignificant result was observed. This result is in line with Malla and Srivastava (2008) who reported a high TRC for Down's syndrome than control subjects. For the male Down's syndrome subjects, the difference was observed in the index and middle fingers bilaterally and the TFRC was only significant on the right in favour of Down's syndrome. For the female subjects, finger ridge count was significant in the right little finger and the left middle finger. From the result it is obvious that the index finger is the most variable digit and little finger the least due to the large proportion of loop in the little finger. Holt 1968, observed same findings. Despite the differences observed in the female ridge fingers, the TFRC of the female Down's syndrome and normal was statistically insignificant on both right and left hands. This is because the female Down's syndrome subjects have more of arches on their fingers and lower whorls than female controls and the male subjects as well leading to low insignificant TFRC when compared with controls or male subjects (Holt, 1968; Verbov, 1970). The variation in the TFRC may be the result of genetic influence on Down's syndrome.

Figure 1 was the schematic diagram showing the summary of the dermatoglyphics features on the palm for both Down's syndrome and control subjects.

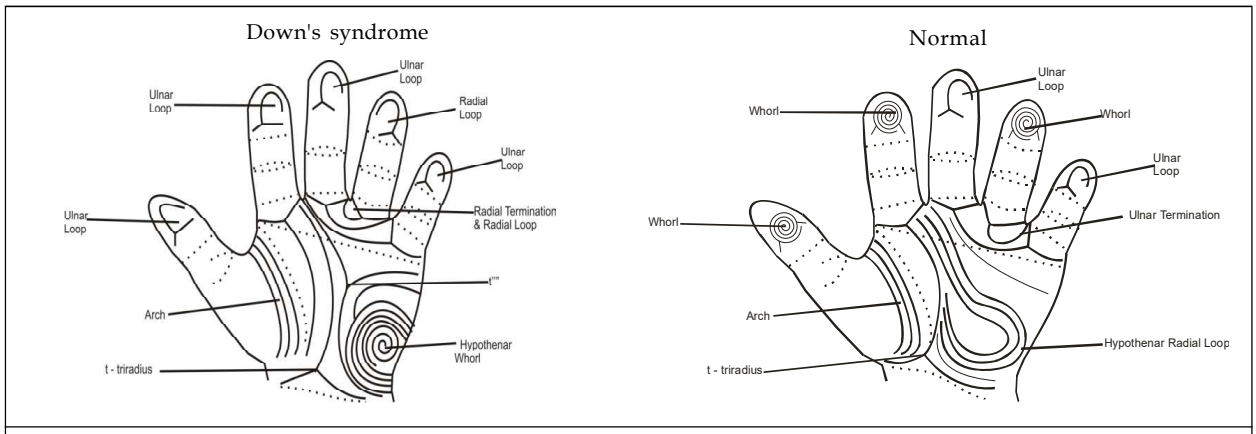

Figure 1: Diagnostic map for Down's syndrome and normal subjects

5. Conclusion

In conclusion, Down's syndrome as compared with the control subjects had an increased ulnar loop on all fingers except finger IV, higher radial loop on the ring finger. Finger ridge pattern and finger ridge count were observed to be significant in the index and middle fingers. These two fingers also are the most variable fingers in the study. High TFRC was observed in both sexes and males subjects except for the female subjects because of the high arches seen on their fingers and these differences are significant on the right hand.

From the results, a strong correlation was observed between dermatoglyphics of Down's syndrome and controls on almost all the parameters studied. Thus from these results dermatoglyphics can serve as an adjunct method in screening both Down's syndrome to aid early detection and bring about early intervention. The study recommends dermatoglyphic as a diagnostic tool in the early screening of Down's syndrome patients in Nigeria.

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