Importance of Palmar Ridge Count in Screening Down's Syndrome

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ABSTRACT

Dermatoglyphics is the study of epidermal ridges of skin. Palmar ridge counts are the ridges found on the surface of the palm between triradius a, b, c, and d. The study aimed to investigate the importance of palmar ridge counts in screening Down's syndrome subjects in Nigeria. Sample size of 101 1(58 males and 43 females) was used for Down's syndrome and 100 1(65 males and 35 females) for control subjects. A descriptive survey design was used, and subjects were conveniently selected from various special and inclusive schools in different part of Nigeria. The data were analyzed using Mann Whitney U test. The trait analyzed were AB ridge count (ABRC), BC ridge count (BCRC) and CD ridge count (CDRC). The results revealed ABRC and BCRC were significantly lower for Down's syndrome when compared to control subjects ($p<0.05$). It was also observed that CDRC was significantly higher for Down's syndrome when compared to control subjects on both hands and for both sexes ($p<0.05$). for male subjects the same result was observed except that the CDRC on the left hand was not significant, while for the female only the ABRC on the left hand was significant different between Down's syndrome and control subjects ($p<0.05$). From this study, ABRC may serve as supportive, low cost adjunct procedure for the screening of Down's syndrome in Nigeria. BCRC and CDRC may serve to support the use of ABRC in screening Down's syndrome. All of these traits may strengthen the early diagnosis and screening of Down's syndrome pending further stronger suggestions.

Keywords: AB ridge count, BC ridge count, CD ridge count, Dermatoglyphics, Screening

INTRODUCTION

Dermatoglyphics is derived from two Greek words "derma" means skin and "glyph" means carve, it is the scientific study of epidermal ridges of skin (both fingerprints and footprints) (Moore, 2003). The Development of dermatoglyphic patterns is under genetic control but can 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. This invariably shows genetic control and the least influences of other environmental factors.

Three types of patterns which are whorls, loops and arches are found on the tips of fingers. The proliferation produces branchings and islands, the minutiae. Minutiae are a detailed morphology of a single ridge which includes branchings, interruptions of the continuity of a ridge, and isolation of short ridge segments (Babler, 1991). These ridges when formed are permanent and never change throughout the life of an individual but only grow in size proportional to the growth of an individual (Bhat *et al.*, 2014). The patterns are determined genetically and modified by environmental forces so that no two persons are exactly alike (Singh & Pal, 2007). The permanency of fingerprint patterns as studied by Galton in 1892 has been the bedrock of genetics in dermatoglyphics. Dermatoglyphics has formed part of the research into human genetics (Verbov, 1970). Although everyone has different fingerprints pattern but then people tend to have certain similar patterns of prints. In 1930s, scholars began to use fingerprints to understand some genetic illnesses and disorders like Down's syndrome. The current trend is that dermatoglyphics has developed to the extent whereby it could be used as a means of diagnosing genetic disorders including Down's syndrome and autism with some level of accuracy.

At the base of digits II to V are seen triradius which are labeled abc& d. Ridges between tri-radius 'a' and 'b' are called a-b ridge count. Ridges between 'b' and 'c' are called b-c ridge count and between 'c' and 'd' is called

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c-d- ridge count. The ABRC is said to be the more satisfactory palmar ridge count because it is genetically controlled (Fang, 1950). b-c and c-d ridge counts are rarely used in dermatoglyphic analysis for medical purposes (Fogle, 1990). However, more recently research reveals both ab ridge count, bc ridge count and cd ridge count as a useful tool in diagnosing autism (Osaat *et al.,* 2019; Oghenemawve *et al.,* 2015).

Embryology Mechanism

Fingerprints are dermal ridge configurations that have grooves in between them (Gray, 2008). The development of epidermal ridges begins between the third and fifth months of fetal age (Moore, 2003). At first epidermal ridges appear in the form of localized cell proliferations around the tenth to eleventh week of gestation. These cell proliferations project into the dermis which inturn projects upwards in the dermal papillae. Later on, there was the appearance of elevations formed on the skin surface known as epidermal ridges. This is known as the primary ridge formation (Namouchi, 2011; Bhat *et al.,* 2014).

As primary ridges develop, the basic ridge configurations are defined. And as the number of primary ridges increase, the ridges continue to increase in dimension. Likewise as primary ridges increase in width, it penetrates deeper into the underlying dermis and as a result, different characteristic patterns are formed, (Babler, 1991; Sandeep *et al.,* 2012). Three types of patterns which are whorls, loops and arches are found on the tips of fingers and toes. The proliferation produces branchings and islands, the minutiae. Minutiae are a detailed morphology of a single ridge which includes branchings, interruptions of the continuity of a ridge, and isolation of short ridge segments (Babler, 1991). The patterns are determined genetically and modified by environmental forces so that no two persons are exactly alike (Singh & Pal, 2007).

At about fourteen (14) weeks, secondary ridges begin to form while the primary ridges cease. Secondary ridges are seen in the form of sweat gland which appears at uniform intervals along the apices of the primary ridges (Babler, 1991). The sweat gland and their ducts continue to elongate and penetrate deeper into the dermis. At this time, the epidermal ridges first begin to appear on the volar surfaces (Lakshmi & Thenmozhi, 2014). By Fifteen (15) weeks, there is the appearance of stratum corneum on the epidermal surface. From the seventeen (17) to twenty four (24) weeks, there is continuous proliferation of the secondary ridges till they correspond one to one with primary ridges.

At twenty four (24) weeks, the epidermal ridge system has taken an adult morphology and dermal papilla begins its development around this period. Till then the morphology of primary and secondary ridges appear as a smooth ridge of tissue. Then other structures, dermal papillae, characteristic of the definitive dermal ridges can be seen (Campbell, 1998). These ridges when formed are permanent and never change throughout the life of an individual but only grow in size proportional to the growth of an individual (Bhat *et al.,* 2014).

During the early month of fetal development when the ridges are in the process of formation, various organs also develop alongside, 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, especially neuronal development so that ridge pattern can be affected by certain abnormalities of early development because once a pattern is established it can never be altered except increase in size (Mollik & Habib, 2011). It is on this ground that dermatoglyphics is correlated with genetic abnormalities, mental illnesses and chromosomal disorders such as down syndrome, autism, diabetes, schizophrenia, etc. (Lainhart *et al.,* 1997; Bulagouda *et al.,* 2013; Singh *et al.,* 2016). 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 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.

Other traits of dermatoglyphics have been related with Down's syndrome subjects, however much work has not be done with respect to dermal ridge count and Down's syndrome especially in Nigeria, therefore the study aimed to investigate the importance of Dermal ridge counts in screening Down's syndrome subjects in Nigeria.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue II February 2026

METHODOLOGY

Research Design

The design for this research is the descriptive sample survey method used to investigate the ABRC, BCRC and CDRC 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. These cities were selected based on the awareness of the people as regards these disorders. They have good numbers of both government and private special/inclusive schools. Again the cities are strategically located within the country.

Research Population and sample size determination

This study comprised both male and female Down's syndrome subjects in Nigeria. Age ranged between 5 to 35 years of age. There was no documented statistical record on the population Down's syndrome subjects in Nigeria. However, Adeyokunnu (1982) reported for Down's syndrome the prevalence rate of 1 in 865 live births.

Sample size was determined using the prevalence rate of Down's syndrome as stated above.

Cochran formula (Daniel, 1999) was used:

$$SS = \frac{Z^2 pq}{d^2}$$

Where *SS* = sample size,

Z = Z-statistic for a level of confidence, 1.96

P = expected prevalence or proportion (in proportion of one for example, 10%, P = 0.1), and

d = precision (in proportion of one; for example if 2.5%, d = 0.025),

q = 1 – p

Prevalence of Down's syndrome was 1 in 865 (P=0.0012) (Adeyokunnu, 1982), d=2.5% (0.025) precision was chosen at 2.5% due to the low prevalence rate, thus enable wider capture of population.

$$SS = \frac{1.96^2 \times 0.0012\ (1 - 0.0012)}{0.025^2}$$

$$SS = \frac{0.004483}{0.000625}$$

SS = 44.83

10% attrition rate of the sample size determined was added = 0.1×44.83= 4.5

Minimum Sample size = 44.83+ 4.5 = 49.

The minimum sample size 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 and Control subjects used was 100 (65 males and 35 females).

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. Information needed for the selection of the subjects was obtained directly from the occupational

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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 Criteria

For a subject to be included in the research, the subjects must be 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.

Exclusion Criteria

The following are the exclusion criteria that were taken for the study.

1. Those with hand or foot anomaly
2. Those who have undergone any surgical procedure on hand and foot which disrupt the ridges
3. Other forms of disorder outside Down's syndrome
4. The children whose parents did not give consent to the procedure.

Methods of Data Collection and Determination

The dermatoglyphic patterns were collected and determined using the scanning method precisely high resolution 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.

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 scanned images were saved in a folder and named appropriately using a tag number to help in the easy identification of the scan images. Later on, collation of raw data was obtained from the scan images and used for further analysis.

Dermal ridge count (ABRC, BCRC and CDRC) involves two triradii. For ABRC the counting were done along the straight line between 'a' tri-radius and 'b'tri-radius points. BCRC was a straight line between 'b' and 'c' tri-radii and CDRC was between 'c' and 'd' tri-radii. An Autocad software was used to count ridges with limited errors after drawing a line across the two triradii for each of the trait.

Test of Reliability of the Instrument

The reliability and measurability of the method (scanning method) were tested using Pearson Moment Correlation Coefficient. The researcher randomly selected ten (10) subjects outside the scope of the study. The subjects' palms were scanned using digital scanner. Some dermatolgyphic traits in the scanned images were collated twice after some week's interval. The final raw data were subjected to analysis using Pearson Moment Correlation Coefficient(r) and average reliability coefficient (r) of 0.95 was obtained. This determines the consistency of the method as well as validating the instrument.

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). Mann-Whitney U test analysis was used to test the palmar/dermal ridge counts (ABRC, BCRC, CDRC). All statistical testing was done at 95% confidence level with p-value less than 0.05($p< 0.05$) taken to be significant.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue II February 2026

Ethical Consideration

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 subject by signing a consent form given to them before samples of the subjects under study were taken.

Limitations of the Study

There are some limitations with regards to this research, they are as follows:

1. Inadequate number of the subjects within the study area.
2. Inaccessibility of subjects due to parental/guardians fear of stigmatization of their children/wards.
3. Lack of related literature because of limited data and information

RESULTS

As shown in table 1, Mann-Whitney U test was used to test for differences between dermal ridge count (ABRC, BCRC, CDRC) of Down's syndrome and control subjects on the right and left hands of both sexes. The results on the right hand showed that ABRC, BCRC CDRC of Down's syndrome subjects was significantly different from those of normal subjects ($p<0.05$), with CDRC having higher mean rank in Down's syndrome than normal subjects. The left hand demonstrated that ABRC, BCRC and CDRC were significantly different in the both groups, CDRC have increased mean for Down's syndrome than normal subjects ($P<0.05$). Table 2, showed Mann-Whitney U test of significantly lower mean rank of ABRC and BCRC in male Down's syndrome and male normal subjects on both right and left hands. CDRC was significantly higher between male Down's syndrome and normal subjects on the right ($p<0.05$). In table 3, the female result on the right hand showed that ABRC, BCRC CDRC of Down's syndrome subjects were not significantly different from those of Normal subjects ($p>0.05$), while the left hand demonstrated that only ABRC was significantly different in the both groups ($P<0.05$).

Table 1: Both sexes comparison

Right dermal Ridge Count	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	**Mann-Whitney U**	**Wilcoxon W**	**Z**	**P-value**
ABRC	DS Subjects	101	88.41	8929.00	3778.00	8929.00	-3.09	**0.00****
	NO Subjects	100	113.72	11372.00				
BCRC	DS Subjects	101	90.53	9143.50	3992.50	9143.50	-2.57	**0.01****
	NO Subjects	100	111.58	11157.50				
CDRC	DS Subjects	101	112.43	11355.50	3895.50	8945.50	-2.80	**0.01****
	NO Subjects	100	89.46	8945.50				
Left dermal ridge count								
ABRC	DS Subjects	101	87.45	8832.50	3681.50	8832.50	-3.32	**0.00****

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue II February 2026

	NO Subjects	100	114.69	11468.50				
BCRC	DS Subjects	101	91.37	9228.50	4077.50	9228.50	-2.36	**0.02****
	NO Subjects	100	110.73	11072.50				
CDRC	DS Subjects	101	110.18	11128.50	4122.50	9172.50	-2.25	**0.02****
	NO Subjects	100	91.73	9172.50				

Note: ** = Significant, DS- Down's syndrome, RC- Ridge count, z- z score, ABRC-AB ridge count, BCRC-BC ridge count, CDRC-CD ridge count.

Table 2: Male comparison

Right Dermal Ridge Count	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	**Mann-Whitney U**	**Wilcoxon W**	**Z**	**P-value**
ABRC	DS FINGER	58	53.18	3084.50	1373.50	3084.50	-2.60	**0.01****
	NORMAL FINGER	65	69.87	4541.50				
BCRC	DS FINGER	58	52.71	3057.00	1346.00	3057.00	-2.74	**0.01****
	NORMAL FINGER	65	70.29	4569.00				
CDRC	DS FINGER	58	69.40	4025.00	1456.00	3601.00	-2.18	**0.03****
	NORMAL FINGER	65	55.40	3601.00				
Left dermal ridge count								
ABRC	DS FINGER	58	53.34	3093.50	1382.50	3093.50	-2.55	**0.01****
	NORMAL FINGER	65	69.73	4532.50				
BCRC	DS FINGER	58	53.27	3089.50	1378.50	3089.50	-2.57	**0.01****
	NORMAL FINGER	65	69.79	4536.50				
CDRC	DS FINGER	58	67.95	3941.00	1540.00	3685.00	-1.75	0.08
	NORMAL FINGER	65	56.69	3685.00				

Note ** - significant, DS – Down's syndrome, z- z score, ABRC –ab ridge count, BCRC – bc ridge count, CDRC-cd ridge count, CDRC-CD ridge count.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue II February 2026

Table 3: Female comparison

Right Dermal Ridge Count	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	P-value
ABRC	DS FINGER	43	35.44	1524.00	578.00	1524.00	-1.76	0.08
	NORMAL FINGER	35	44.49	1557.00				
BCRC	DS FINGER	43	38.03	1635.50	689.50	1635.50	-0.63	0.53
	NORMAL FINGER	35	41.30	1445.50				
CDRC	DS FINGER	43	43.22	1858.50	592.50	1222.50	-1.61	0.11
	NORMAL FINGER	35	34.93	1222.50				
Left DRC								
ABRC	DS FINGER	43	34.73	1493.50	547.50	1493.50	-2.06	**0.04****
	NORMAL FINGER	35	45.36	1587.50				
BCRC	DS FINGER	43	38.09	1638.00	692.00	1638.00	-0.61	0.54
	NORMAL FINGER	35	41.23	1443.00				
CDRC	DS FINGER	43	42.60	1832.00	619.00	1249.00	-1.35	0.18
	NORMAL FINGER	35	35.69	1249.00				

Note: ** = Significant, DS- Down's syndrome, RC- Ridge count, z- z score, ABRC-AB ridge count, BCRC-BC ridge count, CDRC-CD ridge count.

DISCUSSION

ABRC has been shown to be genetically controlled and happened to be the most satisfactory dermal ridge count. As well it is highly correlated with genetic disorders (Verbov, 2007; Sanyaolu *et al.,* 2011, Osaat *et al.,* 2019). Research on twins indicates greater environmental influence on ABRC than finger ridge count (Verbov, 2007). According to Fearon *et al.* (2001) ABRC was found to be significantly lower between Down's syndrome patients and control. The above finding is in line with the present study where Down's syndrome has a decreased value of ABRC when compared to control group bilaterally of both sexes. Hiroshi & Junichi (1971) also reported similar finding, the Down's syndrome in of Japanese population have lower ABRC for Down syndrome than the normal population, though not statistically significant. While for Klinefetters syndrome ABRC was significantly lower than the Japanese population. This means that a-b ridge count appeared to be influenced by sex-chromosome complement. This is also in line with the idea of David (1984). Down's syndrome male subjects also showed significantly lower mean rank of ABRC on both hands than control. ABRC of female Down's syndrome was only significantly lower on the left hand implying sexual dimorphism and bilaterism. It also suggests the influence of sex-

chromosome complement for Down's syndrome. Ozyurt *et al.* (2010) observed a significantly lower ABRC for schizophrenia. Osaat *et al.* (2019) reported a significantly higher ABRC for autism than control subjects.

Like ABRC, there was significantly lower BCRC for Down's syndrome than control subjects while CDRC was observed to be higher for Down's syndrome than normal subjects for both sexes on both hands. In the male subjects only the left CDRC was not significant. As observed for the female subjects, the differences between Down's syndrome and control subjects were not significant except for ABRC on the left hand. This result implies that lower BCRC and higher CDRC can also be used as a good tool in diagnosing Down's syndrome. Also the significant differences observed in the ABRC of both sexes, in males and in females Down's syndrome and control subjects showed that ABRC is genetically determined than the other dermal ridge counts especially in diagnosing Down's syndrome subjects. Ozyurt *et al.* (2010) reported significant decrease in the CDRC in the left hand of schizophrenia subjects and in the right and left hands of female schizophrenics. Though BCRC and CDRC were not known to be important tool in screening of disorder, the result of the present study revealed its importance for both Down's syndrome. Sexual dimorphism observed in favour of the male subjects.

CONCLUSION

This study has revealed the importance of dermal ridge count in the screening of Down's syndrome. It was observed that AB ridge count was more genetically determined than other dermal ridge counts as well correlate better with Down's syndrome in the present study. A lower ABRC was observed for Down's syndrome when compared to control subjects and the difference was statistically significant for both sexes on both hands, for males on both hands while for females the difference was not significant except on the left hand. Again, BCRC was observed to be significantly lower in Down's syndrome than control subjects while CDRC was significantly higher for Down's syndrome than control subjects. From this study, ABRC may serve as supportive, low cost adjunct procedure for the screening of Down's syndrome in Nigeria. BCRC and CDRC will serve to support the use of ABRC in screening Down's syndrome. All of them may strengthen the early diagnosis and screening of Down's syndrome pending further stronger suggestions.

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