VARIATION IN DERMATOGLYPHIC PATTERNS AMONG DIABETICS IN WESTERN UGANDA POPULATION.

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Abstract

Dactyloscopy is a branch of dermatoglyphics (the study of epidermal ridges) which involves assessment and classification of fingerprint patterns for identification. All fingerprint patterns are laid down permanently from the third month of the intra-uterine life and they remain unchanged throughout the life. This is also the time when all organs in the body are finalizing their development. Therefore, a positive association of the dermatoglyphic features with different diseases like diabetes, mongolism, schizophrenia and leprosy have been well documented in the literature. The aim of the present study was to evaluate the dermatoglyphic patterns and the specific variations which may be used as a valuable diagnostic tool for early detection of diabetes mellitus. In this study, 150 diabetic subjects and 150 control were selected from the KIUTH Western Uganda and their fingerprints were taken by the Indian ink method. The print patterns including whorls, arches, ulnar and radial loops were analyzed and the variations were cross-tabulated between sex, the side of the hand and pattern distribution indexes. A significant increase of arch patterns were noted among diabetic patients than in the control group. However, some fingers such as the ring finger completely lacked an arch pattern in both groups. The increase in arches was strongly supported by a significant increase in Dankmeijer’s index. In conclusion, the findings of this study indicate possible markers for the use of dermatoglyphics in early diagnosis of diabetes.

Keywords: Dermatoglyphics, Fingerprint, Diabetes, African countries.

INTRODUCTION

The importance of dermatoglyphics goes back to ancient China in 1839 where it was common practice in the sale of the land (Thoma, 1974). The deed of the land carried the impression of the fingerprints as an acknowledgement of the deed. In addition, there was the prevailing custom of the sale of children in China and the prints of the palm and soles were recorded as a safeguard against the impersonation (Thoma, 1974).

Dermatoglyphics deals with the study of the epidermal ridges and their configurations on the fingers, palms and soles. The word “dermatoglyphics” is derived from the Greek word derma “meaning skin” and “glyphic” meaning carvings (Kiran et al., 2010). Dermal ridge differentiation takes place early in foetal development. The resulting ridge configurations are genetically determined and influenced or modified by environmental forces (Schaumann and Alter, 1976).

Dermatoglyphics are of interest in anthropology, criminology, and medicine, including dysmorphology (the study of congenital malformations) and the study of chromosome abnormalities such as trisomy 21 (Down syndrome) (Anitha et al., 2014). The study of fingerprints as a method of identification is also known as Dactylography or Dactyloscopy (Gutiérrez-Redomero et al., 2014), and currently it is also known as the Henry-Galton system of identification. Dactylography is the process of taking the impressions of papillary ridges of the fingertips for the purpose of identification of a person.

Epidermal ridges and their arrangement (dermatoglyphic patterns) exhibit a number of properties that reflect the biology of an individual (Crawford and Duggirala, 2014). Dermatoglyphic features statistically differ between the sexes, ethnic groups and age categories. Because dermatoglyphics and their components are genetically determined, and the arrangement of ridges remains constant throughout life, they have become of value as a supportive aid in the diagnosis of hereditary disorders (Crawford and Duggirala, 2014). Considerable progress has been made in the understanding of the associations between dermatoglyphics and various medical disorders, and nearly all chromosomal disorders have been known to show dermatoglyphic patterns which can be used as part of preliminary diagnostic tools for such disorders (Yunis, 2012). Therefore, dermatoglyphic analysis has been established as a useful diagnostic and research tool in medicine, providing important insights into the inheritance and embryologic development of many clinical disorders (Anitha et al., 2014).

Currently, dermatoglyphics is involved in the forensic and medical field of research, such as Down’s syndrome, psychosis, bipolar disorders and Diabetes mellitus (Anitha et al., 2014). However, some practitioners misuse dermatoglyphics and conduct fortune-telling instead of proper scientific analysis. This practice is considered a faux pas as dermatoglyphics is based on genetic research instead of baseless predictions (Valdez and Pathak, 2014).

The American Diabetes Association (2010), defines Diabetes Mellitus as a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of different organs, especially the eyes, kidneys, nerves, heart, and blood vessels (Funnell et al., 2011). The prevalence of diabetes mellitus is increasing, particularly in developing countries. It is one of the leading causes of morbidity and mortality and 90% of its etiology is genetically influenced (Whiting et al., 2011). The disease has a strong hereditary background. Offspring of two diabetic parents have an 80% lifetime risk of diabetes (Kenny et al., 1995).

Several significant population specific studies have been carried out to determine the correlation between dermatoglyphics and incidence of diabetes mellitus (Table 5). However, none so far...
have been undertaken in Western Uganda. Therefore, the present study intends to evaluate the relationship between the fingerprint patterns and the incidence of diabetes mellitus in the Western Uganda population. Widespread variation between the ethnic groups occurs, thus there is need to determine the parameter values for use in making a diagnosis in each ethnic group.

**Embryology of fingerprints**

During embryogenesis, the development of epidermal ridges are preceded by the formation of volar pads (swelling of mesenchymal tissue) that first appear as elevations on the palm around 6.5 weeks post fertilization, followed by the five digits approximately one week later. Volar pads exhibit rapid growth between 6.5 and 10.5 weeks. Initially the pads appear evenly rounded; however by the 9th week, the pads begin to vary in both position and shape (Hanbi, 1991).

There have been numerous studies on volar pad development and its influence on friction ridge path configuration and pattern formation, leading to individual uniqueness of finger prints (Champod et al., 2004). Studies have also shown that there is a direct correlation between the location, shape and size of volar pads and friction ridge patterns. The shape of the volar pad can be the result of genetics or external physical influences or a combination of both.

Tensions and pressures in the skin during early embryogenesis were thought to be responsible for determining the directions of the epidermal ridges. Champod (2004) postulated that fingerprint patterns depend on the underlying arrangement of peripheral nerves whilst Fujimoto (2003) suggested that the ridges followed lines of greatest convexity in the embryonic epidermis.

**Dermatoglyphic landmarks and pattern configuration**

**Dermatoglyphic Patterns:**

- The three basic dermatoglyphic Patterns on finger tips are: i) Tri-radius: formed by the confluence of three ridge systems that form angles of approximately 120° with one another; ii) Core: the approximate center of fingerprint pattern and iii) Radiant: which are lines emanating from the tri-radius and enclose the pattern area (Figure 1) (Durham and Plato, 1990).

**Fingertip patterns**

- The ridge patterns on the distal phalanges of the fingertips are divided into the three groups viz: arches, loops, and whorls (Hong and Jain, 1999).

**Arches:** The Arch pattern is made up of ridges lying one above the other in a general arching formation. (Figure 2). The arch pattern is subdivided into two types viz: a) Simple or plain arch composed of ridges that cross the fingertip from one side to the other without recurving; b) Tented arch composed of ridges that meet at a point so that their smooth sweep is interrupted (Maltoni et al., 2009).

**Loops:** The loop pattern consists of one or more free recurving ridges and one delta (Figure 2). The loop pattern is subdivided into two types: a) Ulnar loop composed of ridges that open on the ulnar side and b) Radial loop composed of ridges that open on the radial side (Jain et al., 1999).

**Whorls:** Whorls are seen in about 25-35% of fingerprint patterns encountered. Any fingerprint pattern which contains 2 or more deltas will be a whorl pattern (Figure 2). There are four types of whorl patterns viz: a) Plain whorls consist of one or more ridges which make or tend to make a complete circuit with two deltas. b) Central pocket loop whorls consist of at least one re-curving ridge or an obstruction at right angles to the line of flow, with two deltas, between which when an imaginary line is drawn, no re-curving ridge within the pattern area is cut or touched. c) Double loop whorls consist of two separate and distinct loop formations with two separate and distinct shoulders for each core, two deltas and one or more ridges which make, a complete circuit and d) Accidental whorl is a pattern which possesses some of the requirements for two or more different types or a pattern which conforms to none of the definitions. (Issrani and Sinha, 2013).

In normal individuals, the most predominant finger print patterns are Loops (60-65%) followed by, Whorls (30-35%) and only 5% percent of the total population have arches (Mensvoort, 2013). A high prevalence of universal distribution for the 10 fingers is as follows; Right hand (thumb to little finger): whorl - whorl - ulnar loop - whorl - ulnar loop; Left hand (thumb to little finger): whorl - whorl - ulnar loop - whorl - ulnar loop (Mensvoort, 2013).

**Frequency distribution indices of fingerprint patterns**

The frequency distribution indices are unique fingerprint calculations that can be used to determine an individual’s or a specific population distribution of patterns. These indices cannot be the same within individuals; thus federal bureaus of investigation have frequently used it to identify persons of interest. However, these patterns can be used to determine the fingerprint distribution of one population to another (Issrani and Sinha, 2013). These indices include: Pattern intensity index (PII): (2 ×% whorl ÷% loop) × 100; arch/whorl index of Dankmeijer’s; (% arches ÷% whorl) × 100; and whorl/loop index of Furuhata’s; (% whorl ÷% of loop) × 100 (Mavalwala and Hunt, 1964).

The highest ‘pattern intensity index’ in the world is found in populations located in Australia and the Eskimos in Northern America - in these populations are whorls are predominant, resulting in an average ‘pattern index’ above 15.5 (while in most other populations loops are most common). And the lowest ‘pattern intensity index’ in the world is found in populations located in central Africa, such as the Bushmen and Pygmies - in these population groups arches and whorls are relatively common, resulting in an average ‘pattern index’ below 10 (while in other populations whorls are usually much more common than arches), (Mensvoort, 2013).

**The value of dermatoglyphics in medicine**

Considerable progress has been made in the understanding of the associations between dermatoglyphics and various medical disorders (Table 5). As a result of these advancements dermatoglyphic analysis has been established as a useful
diagnostic and research tool in medicine, providing important insights into the inheritance and embryologic development of many studied clinical disorders (Anitha et al., 2014). Congenital anomalies like trisomy 21 and 46 XY female (Bosco et al., 2001) can have multiple effects on the phenotype, including the pattern of dermatoglyphics (Anitha et al., 2014).

Studies have also shown that dermatoglyphics may be an important feature in psychiatric illness. Schizophrenic cases showed reductions in palmar a-bridge counts (Stosjevic et al., 2013), whereas radial loops are increased in bipolar mood disorder (Chakraborty, 2001). Recent studies observed dermatoglyphics as diagnostic clues to various clinical conditions like acute lymphoblastic leukemia, occupational allergic bronchitis, locomotor disorder, coeliac disease, beta-thalassemia and many others (Mollik and Habib, 2012).

Currently, there are several ongoing studies on the relative frequencies of various dermatoglyphic features for chromosomal disorders. When combined with other clinical features of a particular disease, dermatoglyphics can serve to strengthen a diagnostic impression and may be useful in screening select individuals for additional diagnostic studies (Anitha et al., 2014).

MATERIALS AND METHODS

This prospective study included 300 residents (150 patients with diabetic mellitus and 150 control group) in Bushenyi District, Western Uganda. Diabetic patients were selected from outpatient department of Kampala International University Teaching Hospital (KIUTH) while the control groups with no family history of diabetes were randomly sampled from the surrounding community. After obtaining consent from the respondents, all the subjects were asked to wash and dry their hands to remove dirt and grease. For the collection of fingerprints, a plain glass plate of 12x12 inches was uniformly smeared with a thin layer of black printers ink by using the inking roller, then the rolled impressions of each finger was stamped in the allotted space for that given finger on the data sheet. In this way for each and every individual the entire prints of ten fingers were prepared. The prints were then studied with the aid of a magnifying glass.

In the present study, the arches, whorls, unlar and radial loops were analyzed. All the types of whorls such as concentric, single spiral, double spiral, accidental, and also all the types of composite whorls such as twin loops, central pocket loops, lateral pocket loops, crest ed and knot-crested loops were grouped under the broad category of ‘whorls’. On the other hand, radial and unlar loops (RL and UL) were classified separately. The dermatoglyphic features for both hand and sexes were then evaluated and presented for the control group and diabetic patients separately. Three indices were also calculated on the basis of the frequency distribution of different finger patterns. These included: (a) The pattern intensity index (PII) (2 x % whorl +% loop) +10; (b) Dankmeijer’s index (% arches +% whorl) x 100; and Furuhata’s index (% whorl +% of loop) x 100. A ‘p’ value of <0.05 was recorded as significant (with the corresponding degree of freedom).

RESULTS

Demographics characteristics

A total of 3000 fingerprints (1500 diabetic and 1500 control groups) were analyzed from 300 subjects (150 Diabetic and 150 control groups) for different digital patterns. The mean age of the two groups was 32.7±4.2 and 29.7±5.1 for diabetic and control group respectively. The total number of males and females were 42.3% (127/300) and 57.7% (173/300) respectively (Table1).

General fingerprint patterns

The general frequency (%) distribution of the 300 (3000 fingerprints) participants are shown in Figure 3 as follows; 58.9% (178/300) loops (Ulnar loops 36.3% + Radial loops 22.6%): 4.6% (13/300) arches, while 36.5% (109/300) were whorls. Of the total 138 arches, the left hand had 46.6% (%103) and right was 54.4% (75/138). Total loops (U loops + R loops) on the left hand was 48.6% (858/1767) and right had 51.5% (869/1767), while the total whorls were 52.9% (978/1905) for the left and 47.1% (916/1905) for the right hand.

Frequency distribution of fingerprints between control and diabetic group

Ulnar loops were the most predominant patterns in both hands of diabetic subjects with a frequency of 35.2% (529/1500) followed closely by whorls at 35.1% (529/1500), however, whorls were most predominant in the control group at 37.9% (696/1500) (Table 2). The least pattern observed were arches in both groups; the Control group had the least at 3.2% (48) and diabetic with 6% (90) of the total 1500 fingerprints (Table 2).

Comparison of distribution of fingerprint patterns between control and diabetic groups in relation to gender.

On the control group, (Table 1) ulnar loops were more common on the female side for both hands at 22.67% (340/1500), followed by whorls at 21% (315/1500). The most common pattern for male control group were whorls at 17.5% (262) followed by ulnar loops at 14.6% (219). Arches were the least common pattern in control group at 0.93% (14/1500) followed by arches in females at 2.27% (34/1500).

On the diabetic group (Table 1) the most common pattern were whorls found in both hands of females at 21% (315/1500), followed by ulnar loops at 20.6% (309/1500). The predominant pattern in male diabetic group were radial loops at 31.87% (109/330). Arches were the least common pattern in diabetic subjects at 2.73% (41/1500) followed by arches in females at 3.27% (49/1500).

Frequency distribution indices of fingerprint patterns

The diabetic group had a total of 17.4% Dankmeijer’s whilst the control group had less than half (8.22%) of the same for both male and female subjects (Table 3). Both hands (right and left for control and diabetic) were calculated together to ensure consistency. Descriptive statistics for fingerprint patterns including mean, Standard deviation and Standard of error among diabetic and control subjects are presented in Table 4 respectively.

DISCUSSION

All the 300 (150 Diabetic and 150 control group) participants were adults of consenting age and with a mean 32.7±4.2 years and 29.7±5.1 years of age for diabetic and control groups respectively. However, most diabetic patients were much older than the control groups, this might be because most symptoms of diabetes begins to show in late adulthood except in the case of juvenile diabetes (Funnell et al., 2011). Although the onset and symptoms of diabetes commonly begins at late adulthood, age has no correlation with the fingerprint patterns as they form during intrauterine life and never change. There was a high number female participants at 58.6% (841/1500) for both control and diabetic groups although this was insignificant in the final results as the deference was very small.

In general, the most predominant fingerprint pattern were loops (Ulnar + Radial loops) for both diabetic and control groups at 58%,
followed by whorls at 56% and arches at 4.4% of the total 3000 fingerprints. This finding conforms to the general international distribution of fingerprint patterns as recorded in the literature (Mensvoort, 2013). Arch patterns are rare and were completely absent on the thumbs of all diabetic patients and on the ring fingers of all the 300 participants, however, there was a general significant increase (at a p value of <0.05) of arch patterns in diabetic subjects as compared to the control group.

Most arch and Loop (U loops + R loops) patterns were predominant on the right hand of all subjects at 54.4% ($7^{57}1500$) and 51.5% ($809^{1768}$) respectively, while the whorl pattern was more predominant on the left hand at 52.9% ($57^{1936}$) for both subjects and sexes (Figure 4). On cross-tabulation between the two groups, there was a high number of Arch and radial loop patterns on the right side of diabetic patients at 6.27% and 26.5% (Figure 4), respectively as compared to both sides of the control group; however the control group had a high number of ulnar loops at 40.4% and whors at 39.5% than both hands of the diabetic groups.

Ulnar loops were the most predominant pattern observed in both hands of diabetic subjects at a frequency of 35.2% ($52^{1500}$) followed closely by whorls at 35.1% ($52^{1000}$), while whorls were the most predominant pattern in the control groups at 37.9 ($56^{1500}$) followed by ulna loops at 37.4% ($56^{1500}$). However, the difference between the loops and whorls was very minimal ranging between 2.2 to 2.8%, this was insignificant when subjected to statistical analysis.

The most rare pattern observed were arches (only 4.6% for the 300 respondents) in both groups although the control group had almost half the number of arches at only 3.2% as compared to the diabetic cases at 6% of the total 1500 fingerprints. This was statistically significant at a p value of 0.0932 (<0.05). Several Authors (Table 5) have also noted significant increase in Arch patterns among diabetic groups from different populations and therefore, diabetes mellitus seems to affect the distribution of fingerprint arch patterns.

On a more specific note, ulnar loops were more predominant finger print pattern and were found in the female control groups at 22.67%, followed by whors at 21%, while the most predominant pattern in the diabetic group was whors in females at 21%, followed by ulnar loops at 20.6%.. The predominant pattern for the male control group were whors at 17.5% (262) while for male diabetic group were radial loops at 11.87%. This indicates that the females on both diabetic and control groups had the most predominant ulnar and loop patterns while the male counterparts.

Arch patterns were the least common under the control and were found in the male side at only 0.93%. The same pattern (Archs) was still the least predominant pattern under diabetic group and found in males to at only 2.73% ($41^{1500}$). The female control group had three times the number of arches as compared to their male counterparts at 2.27% of the total 1500 fingerprint studied.

On analysis of unique fingerprint frequency distribution indexes, Furuhata’s index was lower in diabetic than the control groups; however, the Dankmeijer’s index was twice as high (17.4%) in diabetic group than control group (8.22%), this was probably because of the significantly high number of arches in diabetic subjects. The pattern intensity index and Furuhata’s index were high in the control group but with an insignificant percentile differences (Table 3), this was likely because the number of whors and arches were almost near equal in both diabetic and control groups. The lowest pattern intensity indices are below 10% as stated in the above literature (Mensvoort, 2013), therefore the PPI in this study were well below the limit as commonly noted in African countries (Mensvoort, 2013).

CONCLUSION

Several studies done in different regions have significantly identified correlation between different fingerprint patterns and diabetes, however the type of pattern identified varies from one region to another. This may be because of racial dermatoglyphic differences from one region to another. There are also different types of diabetes mellitus and each may present genetically with a different pattern.

Therefore, a more population and disease specific study may be required to confirm the value of dermatoglyphics in early diagnosis of diabetes mellitus. It would also be appropriate to subject results through calculations of frequency distribution indices such as PPI to confirm the significance of the predominant pattern. In the case of this study, statistically significant differences are evident in Arch pattern and Dankmeijer’s fingerprint distribution index.

References


**Figures**

*Fig(1) Illustration of finger print type lines of an ulnar loop.*

*Fig(2) Primary finger print patterns.*
Fig(3) General frequency distribution of fingerprint patterns on the right and left hand.

Tables

Table(1) Comparison of frequency (%) distribution of fingerprint patterns between sexes of control and diabetic groups.

Table(2) Frequency distribution of fingerprint patterns between the control and diabetic groups.

Table(3) Comparison of frequency (%) distribution indices between diabetic and control.

Table(4) Descriptive statistics and a test of significance for control and diabetic subjects.

Table (5) Predominant fingerprint patterns as noted by various authors from different regions.