Applications of Dermatoglyphics in Anthropological Research: A Review

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ABSTRACT: The grooves and the ridges on the fingers, palms and the soles have aroused scientific interest for centuries. This field, known as dermatoglyphics, has a lot of applications in modern day population and medical research research. The present paper focuses on the different aspects of dermatoglyphics and also its applications. A brief account about the development of dermatoglyphic studies in India has also been discussed..

INTRODUCTION

The tiny grooves and fine ridges which form different patterns on the finger, palms and soles have aroused scientific interest for the last 300 years. The word 'dermatoglyphics' was coined by Cummins ('26) and is derived from the two words '*derma*' meaning 'skin' and '*glyphe*' meaning 'curve'. The development of these ridges is the result of the embryogenesis during the 6th week of foetal life when volar pads are formed. Volar pads are little ball-like structures that become apparent and constitute the contour of the developing fetal hand during this 6th week. At this stage the hands remains paddle-like. The volar pads begin to recede around the 13th week then skin ridges begin to appear complimenting the shape of volar pads. By the 19th week, ridge formation is complete. According to Bonnevie ('27), there are a number of factors that are responsible for ridge formation and pattern types. These factors are:

(a) Thickness of the epidermis at the time of ridge differentiation,

(b) A water lodge stage, and

(c) Contour of the embryonic finger pads.

Once the dermatoglyphic characters are formed during the 13th week of foetal life, it remains unchanged throughout the life of an individual. They exhibit wide range of variations in both qualitative and quantitative features in the finger and palmar regions.

Brief History of Dermatoglyphics

The importance of dermatoglyphics (finger and palm prints) goes back to ancient China in the 16th century where it was a common practice in the sale of land holdings. The deed of the land holding carried the impression of the finger prints as an acknowledgement of the deed. There was also a prevailing custom in the sale of the children in ancient China where the prints of the palm and soles were recorded as the safeguard against the impersonation. The first official mention of fingerprints dates back

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to 1684 when Grew lectured at the Royal College of Physicians of London about some interesting markings found on the human finger balls. Two years later, the significant work of Malpighi (1686) on the scientific description of finger prints was published. Two other important milestones were Galton's contributions entitled '*Finger prints*' published in 1892 and '*Finger Prints Dictionaries*' published in 1895.

In fact, Galton (1892), who pioneered the study of dermal patterns in families and racial groups, was the first to lay down the basic methods and principles of dermatoglyphics. The history of the finger print system was subsequently dealt with by Lauter ('12), while Herschel ('16) traced the origin of the finger prints. Cummins ('27) has observed the impression of a thumb in clay. Heindl ('29) reported the first finger print for personal identification in Germany. Cummins ('30) studied the first finger print carving of the Stone Age. Later, Henry ('37) distinguished the four basic finger patterns (arch, loop, whorl and composite) and their further subdivisions. Wilton ('38) published an excellent book entitled, *Finger Prints History, Law and Romance*. Myers in the year 1939 also provided the history of identification of finger prints. Subsequently in 1961, Cummins and Midlo published their book entitled '*Finger Prints, Palms and Soles: An Introduction to Dermatoglyphics*' which is still considered to be the most authentic book in the field of dermatoglyphics. The book was dedicated to one of the pioneers of dermatoglyphics called Harris Hawthorne Wilder. Later, another significant book was published by Schumann and Alter in the year 1976 entitled '*Dermatoglyphics in Medical Disorders*'. Dash Sharma ('84) published '*Current status of dermatoglyphics study in South Asia*', a review article on development of dermatoglyphics studies with special emphasis on India.

Principal Dermatoglyphics Features

Galton (1892) classified finger patterns into three types. These are: Arch, Loop and Whorl. These patterns are distinguished on the absence or presence of triradius. A subsequent classification was formulated by Richard Henry in the year 1900 in which whorl has been further classified into composites, central pocket loops and lateral pockets loops along with a rare type called accidental.

The palmar area is divided into hyothenar, thenar, and I, II, III, and IV intendigital areas. The variables usually studied dermatoglyphics are both qualitative and quantitative. These variables include pattern type, pattern intensity, a-b ridge count, total ridge count, absolute ridge count, *atd* angle, main line formula and main line termination. Bhanu ('75) suggested a classification for the ridge course of the whorls.

Methods of taking prints: Basically prints are of two types, latent print and daub print. In the study of dermatoglyphics, the latent print is the one that is utilized for identification and analysis. The most widely used method is the roll print ink that was developed by Cummins and Midlo ('43). A number of other methods were subsequently developed. These include the method outlined by Katznelson and Goldman ('82) for fetal dermatoglyphics. Techniques have been developed to collect latent prints that have tremendous forensic importance (Sametband *et al*., 2007). A review of the different methods used to fingerprint deceased individuals has been published by Kahana *et al.* (2001). Very recently, electronic scanners are also being utilized for taking finger and palm prints (Rutty *et al*., 2007).

APPLICATIONS OF DERMATOGLYPHICS

Dermatoglyphics are biological traits of human and other primates and it is widely used in anthropological, genetical and medical studies. Dermatoglyphics are very important in the study of population variation, personal identification, twin study, association with diseases, selection of athletes, paternity disputes and primatology, etc. which are briefly discussed below.

Dermatoglyphics in Population Variation Study

Dermatoglypic traits play a significant role in assessing ethnic variation and ethnic affinities and have been extensively utilized in comparative studies of the human population variations for the simple reason that they are under genetic control (Holt, '68; Schaumann and Alter, '76) and not under the influences of ecological and climatic pressure (Hiernaux and Froment, '76). This has also been

corroborated by Bhasin (2007) who also observed that dermatoglyphics being less subjected to environmental influences and polygenic in nature has made it good criterion for population study (Bhasin, 2007). Human population studies using dermatoglyphics traits began with early population descriptions and currently use multivariate approaches for detecting evolutionary processes (Bhasin, 2007). Pioneers like Galton and Wilder made significant contributions using dermatoglyphics in the field of population variation. Two of the earliest studies on population variation in dermatoglyphic variables are by Thoma (1969) on Hungarian individuals and Roberts and Coope (’72) on individuals from United States. Grace (’75) described the digital and palmar dermatoglyphs in a random sample of normal Whites from Durban. Variation in some finger dermatoglyphics patterns in a Spanish population was observed by Esteban and Moral (’93). Arrieta *et al*. (2003) observed variation in digital dermatoglyphics traits among the Basques of Spain. Recently, Scheil *et al*. (2005) reported variations in dermatoglyphics traits among individuals from Europe. Other important studies of mostly European populations include those of Schlauginhaufen (1906), Rife (’53), Thoma (‘’69), Esteban and Moral (’93), Miki *et al*. (’60), Miki and Hasekura (’61), Borbolla *et al*. (’80), Arquimbau *et al*. (’93), Sivakova *et al*. (’95) and Demarchi *et al*., (’97), among others. Extensive studies have been conducted by Indian researchers on ethnic variation in dermatoglyphic traits, notable among them are Biswas (’36); Tiwari (’52); Singh (’55, 2000); Sarkar and Banerjee (’57), Das (’59, ’79); Dash Sharma (’66, ’68, ’73); Das and Das (’65); Chakrabartii and Mukherjee (’61); Chattopadhyay and Dash Sharma (’69); Basu (’71); Sarkar (’69, ’71, ’72); ; Deka and Bora (’73); Malhotra (’79); Singh and Bhasin (’79); Balgir and Sharma (’86); Reddy *et al*. (2000a, 2000b); Reddy and Reddy (2001); Reddy (2006); Kusuma, Babu and Naidu (2002); Karmakar *et al*. (2005); Nrahari, Malati and Dev (2008); Sen and Mondal (2008); Sen, Kanchan and Mondal (2011); Biswas (2011); and many others.

Inheritance Pattern of Different Dermatoglyphics Traits

Rife (’54) observed the polygenic nature of dermatoglyphic variables and highlighted the fact these would be free of assortative mating effect. Some of the earliest studies in this aspect are by Holt (’52), Wendt (’55) and Matsukura (’67). In a family study using twin pairs, Gindilis and Finogenova (’76) observed that all the finger dermatoglyphic characteristics studied had a high degree of genetic determination. Voitenko *et al*. (’79) showed that based on family and population data, finger dermatoglyphics inheritance was polygenic in nature. Tay (’79) evaluated the inheritance of liability estimated from the incidence among individuals using palmer dermatoglyphic variables, while Gilligan *et al*. (’87) evaluated the complex segregation analysis in order to understand the possible genetic effects on various dermatoglyphic traits. Very recently, Reed *et al*. (2006) utilized fingerprints in twin-pairs to estimate heritability for the presence of at least one fingertip arch pattern. Other important contributions are by Slatis *et al*. (’76), de Wilde (’79) and Phelan *et al*. (’81). Inheritance studies on palmar configurations, ridge count, middle phalangeal and basal phalangeal configurations by twin studies, C-line terminations, total number of triradii, pattern intensity index, have been carried out by several Indian researchers, important among them are of Mukherjee (‘’66); Mitra *et al*. (’66); Basu (’68); Kumbnani (’69); Bansal and Bhattacharya (’72); Pateria (’78); Dash Sharma (’71,’94); Holt and Dash Sharma (’77); Sengupta and Karmakar (‘’2004); Karmakar *et el*. (2006); among others.

Dermatoglyphics in Personal Identification

It is now well established that fingerprinting provides the most accurate and precise method of identification of humans and that in modern societies such identification of human remains is necessary for both legal and social reasons (Buchner, ’85). Accordingly, fingerprints remain a helpful tool for investigators in determining personal identification (Polimeni *et al*., 2004). For more than a century, fingerprint evidence has been shown without doubt to be the best form of personal identification yet devised and millions of comparisons and subsequent identifications have been affected worldwide without any error in the system having been detected (Leadbetter, 2005). The fingerprints method of standardization involved the efforts of many

individuals including Grew, Purkinje, Herschel, Faulds, Galton, Henry, and Hoover (Caplan, '90). With the development of newer and sophisticated techniques, it is now possible to obtain images of fingerprints on moist surfaces (Polimeni *et al*., 2004) and of untreated fingerprints on glass backgrounds with excellent ridge details (Tahtouh *et al*., 2005).

Association of Dermatoglyphics with Disease

Considerable progress have been made in the understanding of the associations between dermatoglyphics and various diseases. Dermatoglyphic analysis has now been established as a useful diagnostic and research tool in medicine and provides important insights into the inheritance and embryologic development of many clinical disorders (Schaumann and Opitz, '91). Some of the early studies conducted to document the association between dermatoglyphic traits and diseases are those of Dash Sharma ('70), Singh ('75), Tillner and Majewski ('78), Oorthuys *et al*. ('79), Borbolla *et al*. ('80) and Rignell ('87), and others.

Using dermatoglyphics features it is now possible to diagnose Down's syndrome (Rex and Preus, '82). Dermatoglyphics traits have also proved to be closely associated with chronic mechanic bronchitis (Schemetovs *et al*., 2000). Zivanovic-Posilovic *et al*. (2003) observed that digitopalmar dermatoglyphics was in a position to affirm the existence of genetic predisposition for development of gastric cancer. Other studies include that of Shemetova *et al*. (2000) on allergic bronchitis, and Rudic *et al*. (2005) on larynx cancer.

Dermatoglyphic Studies of Non-Human Primates

There have also been significant scientific contributions towards the understanding of dermatoglyphic patterns among non-human primates. Studies include those among Colobus monkeys (Brehme, '67), Pygmy chimpanzee (Brehme, 1975) and various Old World Monkeys (Newell-Morris, '79). The epidermal pattern frequencies and pattern intensity values of the palms were observed among Howler monkeys (Brehme and Newell-Morris, '81) who made interspecific comparisons and noted sex and side differences. The palmar dermatoglyphic pattern types were determined in three species of Callicebus by Newell-Morris and Wienker ('86) who further discussed the results with reference to the taxonomic classification of the species of Callicebus and their postulated evolutionary history.

Dermatoglyphics and Disputed Paternity

With the closer resemblance of dermatoglyphics among closer relatives than among the unrelated person, the possibility of using dermatoglyphics analysis as a complement means in establishing paternity has been suggested. Li *et al*. (2000) was the first to build a hereditary model of left and right asymmetry in humans which can be used to determine whether a person is the father of another using the of interdigital areas of dermatoglyphics patterns. Another method has also been developed using palm prints to assess parental identification which seems to be more reliable (Zhou *et al*., 2001).

Dermatoglyphics and Sports

Dermatoglyphic is one of the reliable external genetic markers for selection of individuals with high level sportsmanship. Researchers have found that the *atd* angles of exceptional athletes were significantly lower than those in the general population (Shao, '92). Cabral *et al*. (2005) study confirmed the similarity between the juvenile Brazilian female volley ball athletes and the adult male team dermatoglyphical characteristics. Nikitiuk, Filippov and Pokazateli ('82) studied development of anaerobic abilities of 13-15 years old children, by indicators of 60 meters run. Similarly Arutiunian ('88) studied dermatoglyphic markers of children's speed power, and Sergienko ('95) studied finger dermatoglyphics for determination of coordination abilities. Abramova (2003) studied finger dermatoglyphics of track and field sportsmen, while Sergienko and Strikalenko (2005) studied rowers. A study was also conducted among the female fencing athletes by Serhiyenko and Lyshevska (2013). Dermatoglyphics information also indicated anaerobic muscle power (AMP) predisposition (Carlos *et al*. 2013).

DERMATOGLYPHICS STUDY IN INDIA

It was Schlauginhaufen (1906) who was probably the pioneer in studying dermatoglypic patterns among

Indian populations. The popularly known Henry System of Classification as mentioned earlier was actually the contributions of two Indian officers who were the subordinates of Edward Richard Henry , the then Inspector General of Bengal Police (Sodhi and Kaur, 2005). Later on, significant studies were undertaken by Biswas (1936), Tiwari ('52), Singh ('55), Sarkar and Banerjee ('57) and Chakrabartti and Mukherjee ('61). Significant reviews on various studies in dermatoglyphics have also been done in India by Singh (1955) and Singh and Bhasin (1979), among others.

In this context, some of the studies are briefly discussed below.

On Population Variation

There have been a number of significant contributions in the field of population variation in India. Kshatriya *et al*. ('80) tried to explore the relationship between total ridge-count (TRC), pattern intensity index (PII) and between absolute ridge-count (ARC) and observed that the relationship between ARC and PII might be different in different population groups. Das *et al*. ('85a, '85b, '86a and '86b) investigated the distribution of dermatoglyphic traits among different Mongoloid, Muslim, Brahmin and Caste populations of Assam. Sexual dimorphism in dermatoglyphic patterns has been observed in both Hindu and Muslim Gujjar populations by Balgir and Sharma ('86). In a noteworthy study, Reddy *et al*. (2000a) studied the nature and extent of dermatoglyphic variation in northwest India with the help of 28 quantitative variables, 20 finger ridge counts and 8 palmar pattern ridge counts among 12 endogamous populations. They also reanalyzed the published data on genetic markers to make the comparative evaluation study between the two. Reddy *et al*. (2000b) further concluded that in overall the patterns of variation observed in dermatoglyphics and genetic markers are consistent with different dimensions of population structure and that dermatoglyphics conform more to the geographic pattern and less to ethnic resemblance, while the reverse is true in the case of genetic markers. Other studies include that of Basu ('71), Dash Sharma ('77, '79), Pateria ('78), Malhotra ('79), Jantz and Chopra ('83), Reddy and Reddy (2001), Karmakar *et al*. (2005), Narahari *et al*. (2008), Sen and Mondal (2008), among others.

On the Inheritance Pattern of Dermatoglyphics Traits

Some of the pioneering works done in this field were those of Mitra *et al*. ('66), Mukherjee ('66), Basu ('68), Kumbnani ('69), Bansal and Bhattacharya ('72), they observed the inheritance of ridge count, triradii, middle and basal phalangeal patterns, C-line termination types, etc. Bhanu ('75) proposed a classification and method of identification of the direction of courses of ridges inside the pattern area of true whorls. He further identified, named and described nine ridge course types. The inheritance of ridge count of plantar interdigital areas has been studied (Pateria, '78). In their study, Sengupta and Karmakar (2004) concluded that there is an evidence of the existence of a major gene on these dermatoglyphic traits and the transmission of this effect is consistent with Mendelian expectation. Other relevant studies that may be cited here are those of Singh *et al*. ('78), Kusuma *et al*. (2002) and Karmakar *et al*. (2006).

Dermatoglyphics and Disease Association

The association of different diseases and dermatogplyphic features were initially observed in India by Mutalik *et al*. ('69), and Verma ('70). Annapurna *et al*. ('78) in their study on rheumatic heart disease observed that there is a reduced frequency of arches on the finger tips in affected males and increased frequency of whorls in affected females. Joshi *et al*. ('92) studied the relationship between some dermatoglyphics variables and nasobronchial allergic disorders and concluded that there were differences between the patients and their respective controls. Fingertip and palmar dermatoglyphics were studied in patients with rheumatoid arthritis and their matched controls (Taneja *et al*., '93). They concluded that while not many differences were observed in palmar patterns, a low ending of line A was found on both hands of two patients and that fingertip patterns were significantly different in patients compared to controls. Other significant studies include that on congenital heart disease (Ahuja *et al*., '82) and on breast cancer (Chintamani *et al*., 2007).

Dermatoglyphic Studies in North-Eastern India

The north-eastern part of India is composed of the states of Assam, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Manipur and Sikkim. North Bengal is the popular name of the area comprising the districts of Malda, North Dinajpur, South Dinajpur, Darjeeling, Jalpaiguri and Cooch Bihar. The state of Sikkim can also be regarded as a part of this area.

A number of investigators have conducted dermatoglypic studies on different populations residing in the above-mentioned areas. These studies have been mostly related to the typological description of some dermatoglyphic variables to understand the ethnic affinity of the population. However, most of the studies are restricted to Assam and North Bengal.

The dermatoglypic characteristics of the Assamese Hindu Caste population (Brahmin, Kayastha and Kalita) were extensively studied by Das and Das (’65), Das (’79) and Das *et al*. (’86). Studies have also been conducted on the Bodo ethnic groups — Boro Kachari, Mech, Rabha, Garo, Hajong, Moran, Chutiya, Mikir, Lalung, Deuri by Das (’59), Das (’60), Deka and Boro (’73), Deb (’79), Das *et al*. (’80) and Das *et al*., (’85). In North Bengal, although pioneering studies was conducted by Sarkar (’69, ’71, ’72) on the Meche, Oraon, Munda, Rajbanshi, Brahmins, Kayastha, Vaida, Namasudra and Muslim, no further significant studies could be found. It is only recently that Sen and Mondal (2008), Sen *et al*. (2010) and Biswas (2011) have shown the population variations and affinities of the Rajbanshi, Mech population in North Bengal. Sikkim is another state where studies on dermatoglyphic patterns are almost non-existent. A detailed literature search could find only two studies. Miki *et al*. (’60) and Miki and Hasekura (’61) studied the finger and palmer dermatoglyphics of the Lepchas and Khasis.

CONCLUSION

The present paper has briefly discussed on the applications of dermatoglyphics traits in population variation studies, personal identification, inheritance studies, disputed paternity, and association of dermatoglyphics with certain diseases in humans. Each aspect of dermatoglyphics study has greatly contributed to the understanding of human population variation particularly in India as its ethnic groups are greatly endogamous because of its caste structure, a situation which is not so clearly marked in European populations, and elsewhere. It is interesting to note that dermatoglyphic traits are now being used as an indicator for selection in sports. Though it is at a very initial stage it is good to know that researchers are working on this aspect.

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