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Decoding Palmar Dermatoglyphic Traits in Cerebral Palsy: A Quantitative Perspective

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Abstract

Background: *Congenital defects and genetic illnesses, such as cerebral palsy (CP), are among the ailments that present significant health risks. Recent research indicates that genetic factors play a key role in the presentation of cerebral palsy (CP), with estimates of half of cases possibly having a hereditary foundation. The study of the distinct ridge patterns on the palm and sole skin is known as dermatoglyphics, and it has been shown to be a possible biomarker for a number of congenital and developmental diseases. Through the examination of these characteristics, the study aims to advance knowledge of the genetic basis of cerebral palsy and its consequences for early detection and treatment.* ***Materials and Methods:*** *A descriptive cross-sectional method was used in this study to assess palmar dermatoglyphics in cerebral palsy (CP) patients. In order to account for dermatoglyphic variances, a total of 136 participants were included, including 68 people with CP and 68 phenotypically healthy controls that were matched for gender. The subjects' palmar scans were taken using a Canon LiDE 300 flatbed scanner. The Angulus classic mobile application was utilised to measure the 'atd' angle, which is created by joining the triradii 'a', 't', and 'd'. In order to evaluate ridge patterns, a-b ridge counts were also carried out using the Cummins and Midlo method. The quantitative variables (a-b ridge counts and 'atd' angles) were compared between groups using independent t-tests in the statistical analysis, a p-value of less than 0.05 was deemed statistically significant.* ***Results:*** *Upon analysis, the a-b ridge counts as well as the 'atd' angles of both the hands were found to be statistically significantly lower in the case (CP) group as compared to the controls. These results strengthen the fact that the genetics has a role in the presentation of CP and the dermatoglyphic traits may be used as a biomarker in the screening and diagnosis of genetic diseases which may lead to better prognosis.*

Keywords: *atd angle, Cerebral Palsy, Dermatoglyphics, Genetic diseases, Ridge count, Quantitative.*

Introduction

India has the most diversified population in the world in terms of socioeconomic status, language, culture, and racial origin. It is the world's largest country by population and sixth largest by area. From an evolutionary perspective, the Indian subcontinent has acted as a passageway for numerous waves of African migrants who arrived by various land-based and marine routes. Furthermore, genomic research reveals that between 3000 and 8000 BCE, four external ancestral groups with significant genetic diversity from those of the Andaman and Nicobar Islands comprised the population of mainland India. The Caucasoids, Australoids, Mongoloids, and Negritos are the main ethnic groups in India. (Sivasubbu et al., 2019)

The high genetic diversity of the Indian population may account for the large number of rare alleles found there, but the authors also proposed that strong inbreeding practices, which are believed to be common among some Indian subgroups, may be to blame. This would increase the likelihood of harmful alleles arising from founder effects in the population. (Cheena et al, 2015) In India, the recognised rate of birth malformations (per 1000 live births) is 64.4, which is comparable to endemic levels. Similar findings on India's higher genetic burden have been reported by a number of independent studies. (Sivasubbu et al., 2019)

Hereditary or genetic diseases rank highest among human ailments. Even though these circumstances are predetermined at conception, they may manifest at any time. One in twenty hospitalised children has a disease that is mostly genetic; as genetics have a significant role in around half of paediatric illnesses, genetic problems account for one-tenth of paediatric hospital deaths. According to surveys, one in every 200 babies has a substantial chromosomal aberration and at least one in every fifty babies has a major congenital deformity. (Babu et al, 2005)

A common developmental disease, cerebral palsy (CP) was first recognised by William Little in the 1840s. Diagnosis and treatment of this ailment can be challenging because of its wide range of severity, from modest disability to severe cases associated with many concomitant conditions. Along with mental retardation and autism, it is one of the three most common lifetime developmental impairments. Those who are affected, as well as their families, experience significant suffering. (Luca, Moreno-De, 2012)

The primary ways that cerebral palsy manifests are through abnormalities of movement and posture. Because of the growth and maturation of the central nervous system, the clinical picture of a static encephalopathy—where the initial lesion or aberration stays static—may change over time. (Sankar et al, 2005)

The incidence of cerebral palsy (CP) is estimated to be "2 to 2.5 per 1000 live births" worldwide. Its prevalence has not changed in spite of improvements in obstetric care and neonatal management. On the other hand, while neonatal death rates have declined, cerebral palsy's incidence and severity have

grown. Premature births occur more frequently than term births. Most term newborns with cerebral palsy cannot be attributed to complications associated to pregnancy or birth asphyxia. (Sankar et al, 2005)

In addition, aetiology, pathology, and clinical presentation can be used to categorise CP, taking into account both motor and non-motor deficits. But different specialities may use different nomenclature, which could result in different classifications (Rana et al., 2017).

Although the precise origin of cerebral palsy (CP) in babies is still unknown, several variables such as hypoxia, low birth weight, premature placental separation, and improper foetal posture have been linked to the condition. Research indicates that approximately half of instances of cerebral palsy may have a hereditary foundation, making genetics a major effect even though prenatal and postnatal environmental factors are secondary contributors. Individual attributes are determined by genes, which are made of DNA. Small differences, or alleles, provide distinctive characteristics. According to Cvjetičanin et al. (2019), the pathophysiology of cerebral palsy is associated with genetic alterations that interfere with regular cellular processes, including genomic variation, copy number variation, epigenetic modifications, and mitochondrial inheritance.

Differences in the occurrence of cerebral palsy (CP) between men and women may be related to neurobiological abnormalities, hormonal impacts, and genetic vulnerabilities. Several genetic mutations and copy number variants (CNVs) linked to CP have been found through studies; certain mutations are more prevalent in females (Cvjetičanin et al., 2019). A thorough neurological examination, routine developmental screening for high-risk infants, and evaluation of important risk factors, such as maternal, obstetric, and perinatal histories, are all part of the clinical diagnosis of cerebral palsy (CP). Critical observation of the child in several situations is also necessary, including supine, prone, sitting, standing, walking, and running (Sankar et al., 2005).

With rare exceptions, diagnosing cerebral palsy in newborns less than six months of age is difficult. Atypical muscular tone, which can be either hypertonic or hypotonic, and delayed developmental milestones are common symptoms of cerebral palsy. Hypotonic situations convert into spasticity by the ages of two-three. It can take up to a year to diagnose with precision; mild cases may need several tests and prolonged observation to confirm the diagnosis (Sankar et al., 2005).

CP is controlled using an interdisciplinary strategy that combines a variety of therapy, despite the fact that it cannot be cured. In order to avoid further difficulties and improve the child's developmental potential, the main objective is to attend to the medical, surgical, developmental, and physical needs of the child. It has been demonstrated that children with CP can function much better while receiving traditional physical and occupational treatments (O'Callaghan et al., 2009).

The study of the distinct ridge patterns—such as whorls, loops, arches, and ridges—found on the volar surfaces of primate hands and feet is known as dermatoglyphics. These patterns are set throughout foetal development and don't change over the course of a person's life. After being identified as

inherited characteristics by Sir Francis Galton in the late 1800s, dermatoglyphics has developed and become relevant in anthropology, forensic science, and genetics. It is essential to comprehending population genetics, human migration, and genetic processes. The field of dermatoglyphics began to investigate the connections between medical conditions and fingerprint patterns in the middle of the 20th century. Cummins made significant contributions to our knowledge of the differences between ethnic groups' palmar and plantar patterns. Dermatoglyphics, the study of the relationships between fingerprint characteristics and inherited illnesses, entered the field of medical genetics. New developments in technology, such computer-based image processing, have facilitated research on the heredity of patterns and their possible links to personality, cognition, and health.

According to Mulvihill and Smith, skin patterns are influenced by the shape of the hand, foot, and embryonic volar pads, which reflect developmental events that occur throughout the embryonic phase. Postnatal patterns, particularly when large ridges emerge, show the height and structure of the embryonic pads during their regression period. Pad regression happened rapidly in places with no pattern on the palm and proximal appendages (Murphy et al., 2006).

Dermatoglyphic patterns are divided into: the number of triradii (ridge intersections) on digits, arches, loops, and whorls. Triradii and patterns delineate regions on the palms and soles; the position of the axial triradius determines the pattern on the palms. The soles have a triradii structure similar to the palm.

Due to their shared embryonic origin, dermatoglyphics are valuable biological indicators of aberrant neurodevelopment in mental illnesses. The development of midline brain areas from the ectoderm occurs at the same time as dermal ridge creation. Studies on brain imaging have revealed structural anomalies, such as cortical alterations, increased ventricular space, and grey matter loss, in disorders including bipolar disorder and schizophrenia. Early embryonic alterations may be the cause of both these anomalies in the brain and unusual dermatoglyphic patterns (Ahmed-Popova et al., 2014).

The aim of the study was to study whether there are any characteristic quantitative palmar dermatoglyphic traits in individuals suffering from Cerebral Palsy. The null hypothesis was taken to be as no significant characteristic quantitative palmar dermatoglyphic traits associated with Cerebral Palsy. The alternate hypothesis states that there are significant characteristic quantitative palmar dermatoglyphic traits associated with Cerebral Palsy.

Materials and Methods:

For the study, the descriptive approach was employed, which entailed gathering information to verify the hypothesis. The cross-sectional strategy was chosen for the current study from among the various approaches utilised in the descriptive research.

The study included a total sample of 136 participants which were categorised based on the case group containing 68 individuals with Cerebral Palsy and the control group containing 68 individuals who

were phenotypically healthy. Both the groups were matched for gender based on rationale of the dependence of dermatoglyphs on the gender. The studied age group was in the range of 4-18 years. The individuals with any palmar abnormality in the form of scar/ deformity/ injury/ skin infection/ spasticity were excluded from the study. Canon LiDE 300, a fast and compact Flatbed Scanner was used to capture the scans of the palms. Angulus classic, a mobile app which can be used to measure angles on images and videos, was used to measure the 'atd' angle on the palmar scans as a quantitative parameter.

'atd' angle is the angle formed by drawing the lines from tridraius 'a' to triradius 't' and from tridraius 't' to triradius 'd', which are present as the intrsections of the three ridge patterns occurring on the palms. The right and the lerft 'a-b' palmar ridge counts were taken by counting the ridges between 'a' and 'b' triradii.

Consent for participation in the study was sought from the participants or their caregivers after explaining the aim and the detailed procedure. Institutional ethical clearance was granted by the IEB (PM/ETHICAL/PT/2023/001).

After a thorough cleaning of both the hands with soap and water, the participants were told to pat dry their hands. The left and right hands' digital and palmar scans were then obtained using an electronic flatbed scanner, Canon LiDE300. To avoid applying too much pressure, the palms were positioned lightly palm-down on the scanner.
With the aid of an online protractor tool (Angulus classic), the 'atd' angle was calculated from the palmar scans. Using the technique developed by Cummins and Midlo, both the digital and palmar scans were examined to evaluate and record 'a-b' ridge counts (2009, T. Polovina-Prološčić).

Version 20.0 of IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp, was used for statistical analysis. The difference in the quantitative variables, 'a-b' ridge count, the 'atd' angle of the left and right hands, between the two groups were determined using the sample t test. A p-value of less than 0.05 was deemed statistically significant.

Results:

The demographic data of the participants revealed that the mean age of the case group was 14.38 ± 4.91 years, while that of the control group was 21.68 ± 1.9 years. Both the groups were matched for gender, where, 29 females and 39 males constituted each group.

The mean value of left and right 'a-b' ridge count of the two groups are depicted in table 1.

Table 1: Comparison of 'a-b' ridge counts between the two groups

Group	Left a-b ridge count	Right a-b ridge count
Case Group	19.31 ± 6.13	23.12 ± 7.3

Control Group	34.74±5.63	34.35 ± 6.36
p value	0.000	0.000

The differences in the mean values of 'atd' angles of both the hands, between the two groups are shown in table 2.

Table 2: Comparison of 'atd' angle between the two groups

Group	**Left 'atd' angle (in degrees)**	**Right 'atd' angle (in degrees)**
Case Group	43.14 ± 10.54	45.73 ± 10.21
Control Group	50.24 ± 4.98	49.23 ± 4.97
p value	0.000	0.012

Discussion

A neurological condition known as cerebral palsy impairs the motor system of the body, placing a financial, social, and physical strain on society as a whole as well as the affected family. When a precise diagnosis is achieved early on and leads to an early intervention, the results of the intervention may be beneficial for the motor symptoms. This is not entirely feasible in the current situation because the diagnosis is based on the patient's medical history and observations of the signs and symptoms as they emerge. This frequently causes a delay in the treatment of the symptoms because the compromised somatosensory system has already established abnormal tone and synergies, which lowers the prognosis. Therefore, a diagnostic tool that aids in the earliest possible discovery of the condition, enables appropriate management, and lessens the cost on society is required. Dermatoglyphics is a new screening and diagnostic technique that claims to be easy, affordable, and practical to use from a young age forward, with the added benefit of having lifelong, unchanging prints. Furthermore, the polygenic system, or locus for CP, is identical to the polygenic system with a small additive effect from each gene in the dermatoglyphic pattern development. (Cvjetičanin, 2019)

The goal of the current study was to examine the quantitative aspects of dermatoglyphics linked to people with cerebral palsy. The study compared cerebral palsy with healthy participants who provided quantitative dermatoglyphic data. The CP patient group was shown to have distinct characteristic trait findings.

After our study's analysis, the values for the left and right 'atd' angles showed a significant difference

between the two groups (p=0.000 and p=0.012, respectively), where the case group reported a lower angle in comparison to the controls. However, Cvjetičanin (2017) observed that there were statistically non-significant differences (p=0.816) in the bilateral 'atd' angles between the female patients with cerebral palsy and the healthy controls. This may be explained by variations in these parameters based on gender and demographics, which are closely linked to the degree of nervous system maldevelopment. Simsek (1998) discovered that the females had a higher 'atd' angle value.

Saldanha et al. looked at the 'atd' angle in individuals with Down syndrome in their 2017 study. The study found that people with Down syndrome had a consistently higher atd angle across multiple populations, indicating the 'atd' angle's potential as a diagnostic marker for the genetic condition. Ramesh et al. (2010) looked into dermatoglyphic variations in children with autism. The researchers discovered that children with ASD had a greater incidence of abnormal 'atd' angles in comparison to neurotypical youngsters. The findings suggest a potential connection between dermatoglyphic anomalies, like differences in the 'atd' angle, and neurodevelopmental disorders like autism.

In their 1988 study, Kobyliansky and Micle focused on dermatoglyphic patterns in patients with Klinefelter syndrome. The results of the investigation showed that there was a significant difference between the 'atd' angle of the affected group and the control group. Patients with Klinefelter syndrome in particular showed larger 'atd' angles, which could be connected to the chromosomal defects that define this condition. In a study by Rodewald et al., the 'atd' angle and other dermatoglyphic patterns were looked at in individuals with Turner syndrome (1994). The researchers found that patients with Turner syndrome displayed a distinct pattern of larger 'atd' angles, suggesting that dermatoglyphic traits could be utilised as supplementary diagnostic instruments to help distinguish this genetic disorder.

A study by Cummins and Midlo (1961) examined gender differences in dermatoglyphics, which includes the 'atd' angle. They claimed that men's 'atd' angles were often greater than women's. This difference was observed across all ethnic groups under investigation, indicating a potential role for sex-specific genetic characteristics (Cummins & Midlo, 1961). The ability to think clearly, perform well physically, and be agile has all been represented by the 'atd' angle; these traits may be related to a person's sex chromosome.

In a 2006 study, Mathew et al. looked into the dermatoglyphic patterns of children with cerebral palsy. The researchers found significant variations between the 'atd' angle of children with CP and that of the control group. Greater 'atd' angles are commonly observed in children with CP, which may be a sign of abnormalities with foetal development that affect both the brain and dermatoglyphic features.

The current study's findings indicate that there are statistically significant variations (p=0.000) in the 'a-b' ridge counts of both hands between the case group and the controls. Cvjetičanin (2017) discovered similar outcomes, showing a statistically significant difference in the 'a-b' ridge count

between the two groups under investigation. But in their investigation, no such distinction between the 'a-c' and 'c-d' ridge counts was discovered. The basis for examining the 'a-b' ridge count exclusively in the current study was established by literature, which also demonstrates a direct association between the 'a-b' ridge count and variations in the nervous system's normal development.

Studies examining differences in ridge counts among individuals with genetic or medical conditions have shown some intriguing connections. These findings may help explain the underlying genetic influences on dermatoglyphic patterns. Individuals with Down syndrome often exhibit characteristic dermatoglyphic patterns, including increased counts of ridges. According to Penrose and Ohara (1973), compared to the general population, people with Down syndrome often have unique fingerprint patterns, such as ulnar loops and single transverse palmar crevices, as well as a higher total finger ridge count (TFRC).

In 2019, Polovina-Prološčić et al. examined the print patterns of children affected by cerebral palsy and compared them with those of their relatives. Upon analysis, significant findings were discovered regarding the total number of ridges in various fingers on both hands. On quantitative features spanning all ten digits, both male and female CP participants showed statistically significant results. These investigations suggest that ridge counts and dermatoglyphic patterns can be utilised as diagnostic instruments to illuminate the genetic and medical causes of a variety of illnesses.

These results contribute to the growing body of evidence supporting the hypothesis that the dermatoglyphics of CP patients are distinct from those of healthy normal subjects because they reflect aberrant or maladaptive CNS development. There are numerous ramifications for these findings. They first suggest using dermatoglyphic analysis as an extra CP diagnostic method, which offers a non-invasive means of identifying individuals who might be at risk. Secondly, these differences emphasise how important it is to consider both environmental and inherited elements when figuring out the cause of cerebral palsy. Further investigation is necessary to identify the specific genetic and epigenetic components causing the disease, since the dermatoglyphic abnormalities that have been reported may be a sign of more widespread developmental anomalies.

In summary, the results of our study indicate that there exist significant differences in dermatoglyphic traits (quantitative), between individuals with cerebral palsy (CP) and healthy controls. These findings highlight the role that genetic and developmental factors play in the aetiology of CP and support the use of dermatoglyphic analysis as a non-invasive diagnostic method. Future research should concentrate on elucidating the underlying mechanisms of these dermatoglyphic variations and exploring their clinical implications for diagnosis and therapy.

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