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Gender-Wise Comparison of Dermatoglyphic Patterns in Autistic and Neurotypical Children: A Comparative Study

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Abstract

Background: Dermatoglyphics, the study of unique, immutable epidermal ridge patterns, emerges from the same embryological ectoderm as the nervous system during early gestation. This shared origin posits it as a potential phenotypic marker for neurodevelopmental anomalies like autism spectrum disorder (ASD). Most studies are from Western populations, with a paucity of gender-stratified data from South Asia. ***Objectives:*** This study aimed to conduct a gender-wise comparative analysis of digital dermatoglyphic patterns between autistic and neurotypical children in Northern Bangladesh, to identify potential pattern deviations associated with ASD. ***Methods:*** This cross-sectional analytical study enrolled 100 Bangladeshi children aged 5–15 years: 50 diagnosed with ASD (38 male, 12 female) and 50 age-matched neurotypical controls (26 male, 24 female). Bilateral fingerprints were acquired using a ZKT ECO biometric scanner and classified into Arch (A), Ulnar Loop (UL), Radial Loop (RL), and Whorl (W) patterns using DigiDoctors software (v1.0.1). Statistical analysis was performed using SPSS v23.0, employing Chi-square and Fisher's exact tests where appropriate. A p-value <0.05 was considered significant. ***Results:*** Significant inter-group differences were observed ($p<0.001$). The autistic group exhibited a higher frequency of: Arch (12.6% vs. 4.4%; OR=3.15, 95% CI: 1.89-5.25), Whorl (36.4% vs. 32.4%), and Radial Loop (3.6% vs. 1.2%). Ulnar Loops were significantly lower in the autistic group (47.4% vs. 61.6%). Gender-stratified analysis revealed autistic males had significantly higher frequencies of Arch, Whorl, and Radial Loop compared to neurotypical males. Autistic females showed a pronounced increase in Arch pattern (16.67% vs. 2.92%; $p<0.001$) but lower frequencies of Whorl and Radial Loop. Radial Loops were absent in autistic females. ***Conclusion:*** This study provides the first gender-stratified dermatoglyphic profile of autistic children in Bangladesh, revealing distinct pattern deviations that differ between males and females. The findings support the hypothesis of altered ectodermal development in ASD and suggest dermatoglyphics could serve as a low-cost, non-invasive adjunctive tool in multidisciplinary ASD assessment, particularly in resource-limited settings. Further large-scale, familial, and genetic correlational studies are warranted.

Keywords: Dermatoglyphics, Autism Spectrum Disorder, Fingerprint, Neurodevelopment, Bangladesh.

INTRODUCTION

Dermatoglyphics, derived from the Greek derma (Skin) and glyphics (to carve), represents the scientific study of the intricate ridge patterns on human fingers, palms, soles, and toes [1]. These patterns are formed between the 10th and 24th weeks of gestation from the volar pads and are permanently fixed by birth, remaining immutable throughout life except for changes in dimension with growth [2, 3]. Critically, this period of ridge differentiation coincides with the early development of the central nervous system, as both structures originate from the embryonic ectoderm. This temporal and embryological synchrony has long fueled the hypothesis that dermatoglyphic anomalies could serve as external markers of atypical neurodevelopment [4, 5].

Autism Spectrum Disorder (ASD) is a heterogeneous, lifelong neurodevelopmental condition characterized by persistent deficits in social communication and interaction, alongside restricted, repetitive patterns of behavior, interests, or activities [6]. Its global prevalence is estimated at 1 in 54 children, with a pronounced male-to-female ratio of approximately 4:1,

suggesting potential sex-linked etiological factors [7, 8]. The pathogenesis of ASD is multifactorial, involving a complex interplay of strong genetic predispositions, epigenetic modifications, and environmental influences [9, 10]. In Bangladesh, awareness and diagnosis of ASD have been increasing, though robust national epidemiological data and research into biological markers remain limited [11]. The search for reliable, objective biomarkers in ASD is a critical area of research to aid in early identification, which is crucial for initiating timely interventions [12]. Dermatoglyphics, being a stable, easily recordable, and cost-effective phenotypic trait, presents a promising candidate. Over five decades of research have yielded inconsistent results: some studies report increased frequencies of Arches and Radial Loops in autistic individuals [13, 14], others note a higher Whorl count [15], while a few find no significant differences [16]. This inconsistency may stem from methodological variations, small sample sizes, lack of gender stratification, and importantly, significant ethnic and population-specific variations in baseline dermatoglyphic patterns [17]. No prior study has provided a detailed, gender-wise dermatoglyphic analysis of autistic children in the Bangladeshi population. This study aims to fill this gap by conducting a systematic comparison of digital dermatoglyphic patterns between autistic and neurotypical Bangladeshi children, with separate analyses for males and females. We hypothesize that autistic children will exhibit significant deviations from the established normative dermatoglyphic patterns of their neurotypical peers, and that these deviations will manifest differently between sexes, potentially reflecting the gendered nature of ASD prevalence and etiology.

MATERIALS AND METHODS

This was a cross-sectional, analytical, case-control study conducted over 12-month period from January to December 2019. The study was conducted in the Department of Anatomy, Rangpur Medical College, Rangpur, a tertiary care teaching hospital in Northern Bangladesh. The study protocol was reviewed and approved by the Institutional Ethical Review Board (IERB) of Rangpur Medical College. A total of 100 children aged 5 to 15 years were enrolled through purposive sampling. The case group comprised 50 children (38 males, 12 females) with a formal clinical diagnosis of ASD according to DSM-5 criteria [6], recruited from specialized autism schools in Dinajpur and Rangpur districts. The control group consisted of 50 neurotypical children (26 males, 24 females) with no history of neurodevelopmental, psychiatric, or major genetic disorders, recruited from local mainstream schools. Written informed consent was obtained from the parents or legal guardians of all participants. Assent was obtained from children where developmentally appropriate.

Inclusion Criteria (for both groups):

- Age 5–15 years.
- Bangladeshi ethnicity (both parents and all grandparents).
- Provision of informed consent/assent.

Exclusion Criteria (for both groups):

- Other congenital/syndromic conditions (e.g., Down syndrome).
- Significant digital trauma/burns.
- Other neurological disorders (except ASD in cases).
- Being a first-degree relative of another participant.

All fingerprint data were collected by a single trained investigator to ensure consistency. Prior to printing, participants' hands were cleansed with soap and water and thoroughly dried. Bilateral digital prints from all ten fingers were obtained using a standardized, non-invasive method with a ZKT ECO Biometric Scanner (Model: ZK9500). The captured images were automatically processed and stored using the dedicated software Digi Doctors, version 1.0.1. Each fingerprint was visually screened on-screen and categorized into one of four primary patterns according to the modified Henry classification system [18]:

1. **Arch (A):** Ridges enter from one side, rise in the center, and exit the opposite side.
2. **Loop (L):** Ridges enter from one side, recurve, and exit the same side. These were sub-classified as:
   - **Ulnar Loop (UL):** Opens towards the ulnar side (little finger).
   - **Radial Loop (RL):** Opens towards the radial side (thumb).
3. **Whorl (W):** Ridges form concentric circles, spirals, or a double loop around a central core.

Ambiguous patterns were reviewed by a second investigator, and a consensus was reached. A total of 1000 fingerprints (10 fingers × 100 children) were analyzed. Data were entered into a Microsoft Excel spreadsheet and analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM Corp., Armonk, NY). Descriptive statistics were presented as frequencies and percentages for categorical variables (fingerprint patterns). Inter-group comparisons (Autistic vs. Neurotypical; Male vs. Female within groups) were performed using the Chi-square (χ^2) test. For cells with expected counts less than 5, Fisher's Exact Test was employed. Odds Ratios (OR) with 95% Confidence Intervals (CI) were calculated for significant pattern differences. A two-tailed p-value of less than 0.05 was considered statistically significant.

Arch	Whorl	Ulnar loop	Radial loop

Figure 1: Different Finger Print Patterns (Arches, Loops and Whorls)

RESULTS

The study comprised 100 children with a mean age of 9.2 ± 2.8 years. The autistic group consisted of 38 males and 12 females, yielding a male-to-female ratio of 3.2:1. In contrast, the neurotypical control group included 26 males and 24 females, with a ratio of 1.1:1. This distribution reflects the well-documented gender disparity in the prevalence of autism spectrum disorder (ASD).

Table 1: Overall Distribution of Fingerprint Patterns in Autistic and Neurotypical Children (N=1000 fingerprints)

Pattern	Autistic Group (n=500)	Neurotypical Group (n=500)	χ^2 Value	p-value	Odds Ratio (95% CI)
Ulnar Loop	237 (47.4%)	308 (61.6%)	25.71	<0.001	0.56 (0.44 - 0.72)
Whorl	182 (36.4%)	162 (32.4%)	2.02	0.155	1.19 (0.93 - 1.54)
Arch	63 (12.6%)	22 (4.4%)	25.84	<0.001	3.15 (1.89 - 5.25)
Radial Loop	18 (3.6%)	6 (1.2%)	7.14	0.008	3.06 (1.20 - 7.80)

****p<0.05 considered significant.**

Analysis of 1,000 fingerprints (500 per group) revealed significant differences in pattern frequencies between autistic and neurotypical children (χ^2 test, p<0.001). While the Ulnar Loop was the most common pattern in both cohorts, its prevalence was significantly lower in the autistic group (47.4% vs. 61.6%; OR=0.56, 95% CI: 0.44–0.72). Conversely, autistic children exhibited significantly higher frequencies of Arches (12.6% vs. 4.4%; OR=3.15, 95% CI: 1.89–5.25) and Radial Loops (3.6% vs. 1.2%; OR=3.06, 95% CI: 1.20–7.80). The frequency of Whorls did not differ significantly between groups (36.4% vs. 32.4%; p=0.155) (Table 1).

Table 2: Gender-Wise Comparison of Fingerprint Patterns in Autistic vs. Neurotypical Children

Pattern	Male			Female		
	Autistic (n=380)	Neurotypical (n=260)	p-value	Autistic (n=120)	Neurotypical (n=240)	p-value
Ulnar Loop	168 (44.21%)	159 (61.15%)	<0.001	69 (57.50%)	149 (62.08%)	0.402
Whorl	151 (39.74%)	84 (32.31%)	0.049	31 (25.83%)	80 (33.33%)	0.145
Arch	43 (11.32%)	15 (5.77%)	0.012	20 (16.67%)	7 (2.92%)	<0.001
Radial Loop	18 (4.73%)	2 (0.77%)	0.002	0 (0.00%)	4 (1.67%)	0.578*

***Fisher's Exact Test**

Gender-stratified analysis revealed distinct dermatoglyphic profiles for autistic males and females (Table 2). Compared to neurotypical males, autistic males showed a significant decrease in Ulnar Loops (44.21% vs. 61.15%; p<0.001) and significant increases in Whorls (39.74% vs. 32.31%; p=0.049), Arches (11.32% vs. 5.77%; p=0.012), and Radial Loops (4.73% vs. 0.77%; p=0.002).

In contrast, autistic females differed primarily in the Arch pattern, which was markedly more frequent than in neurotypical females (16.67% vs. 2.92%; p<0.001). Radial Loops were entirely absent in autistic females, while frequencies of Ulnar Loops and Whorls did not differ significantly between female groups (p=0.402 and p=0.145, respectively). These gender-specific trends are visually summarized in Figures 2 and 3.

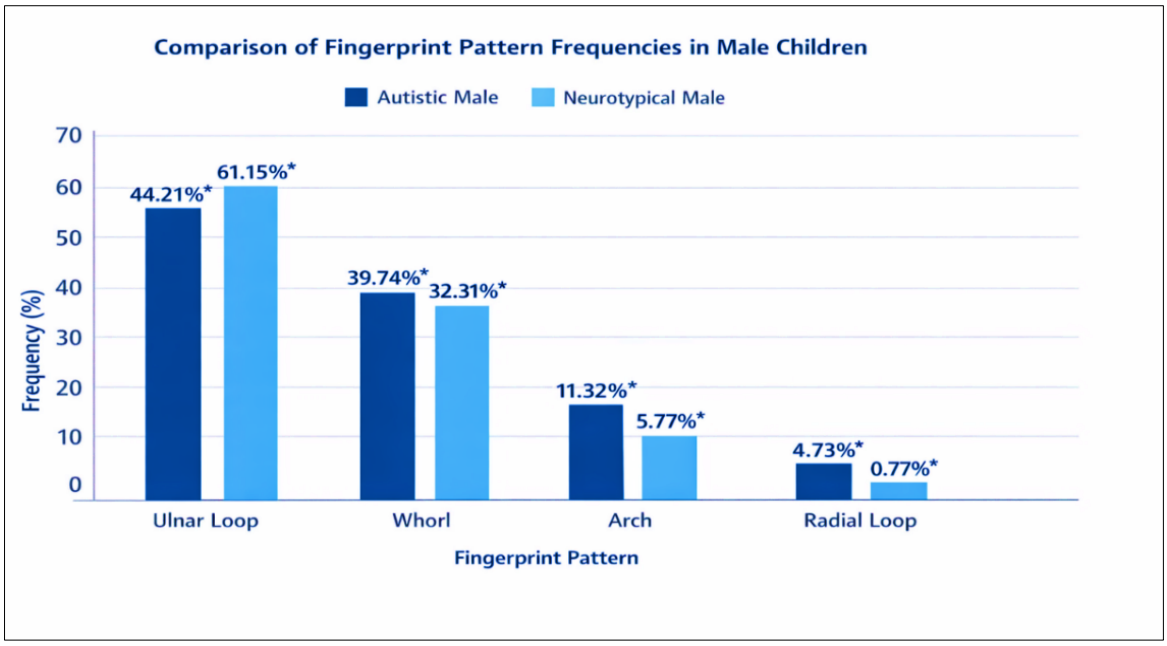

Figure 2: Bar diagram comparing the percentage frequency of fingerprint patterns between autistic and neurotypical males

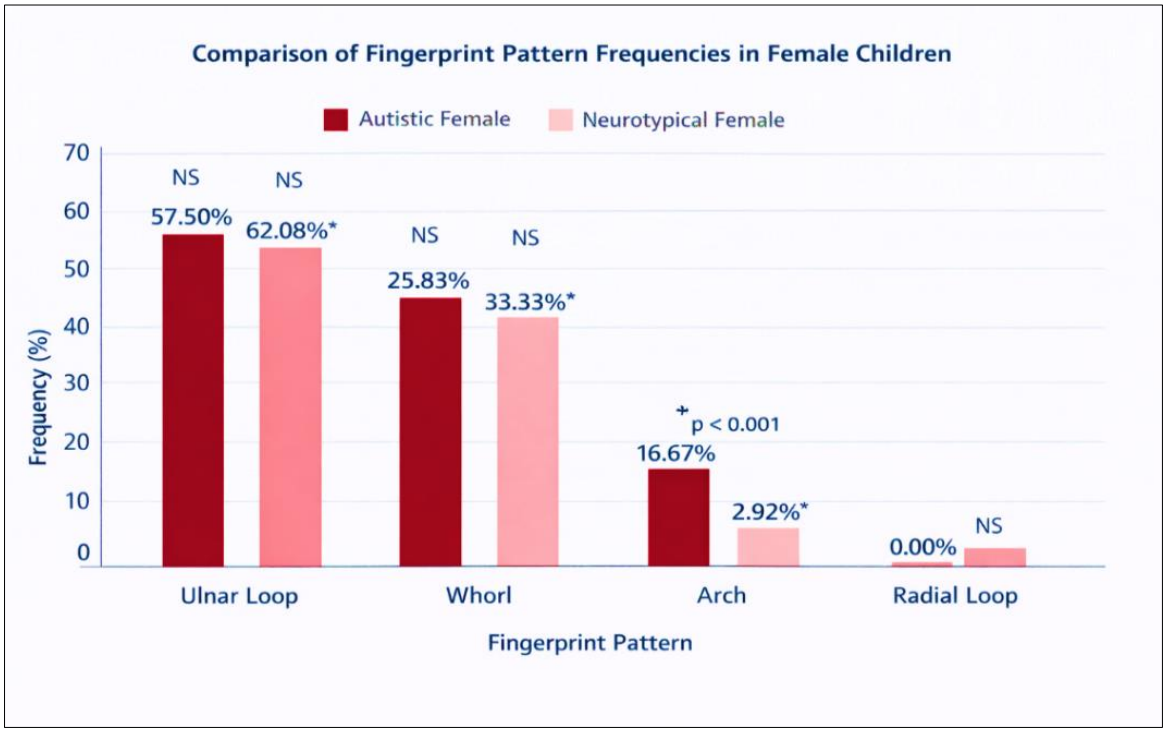

Figure 3: Bar diagram comparing the percentage frequency of fingerprint patterns between autistic and neurotypical females

Table 3: Distribution of Fingerprint Patterns by Hand in Autistic Children

Pattern	Right Hand (n=250)	Left Hand (n=250)	p-value
Ulnar Loop	122 (48.8%)	115 (46.0%)	0.523
Whorl	84 (33.6%)	98 (39.2%)	0.178
Arch	37 (14.8%)	26 (10.4%)	0.130
Radial Loop	7 (2.8%)	11 (4.4%)	0.353

No statistically significant differences were found between the right and left hands for any pattern type within the autistic group, indicating bilateral symmetry in the observed deviations. An exploratory analysis was conducted to identify if specific digits showed a propensity for certain patterns.

Table 4: Frequency of Arch Pattern Across Individual Fingers in Autistic Children

Finger (I to V)	Right Hand	Left Hand	Total (n=63 Arches)
I (Thumb)	2	2	4 (6.3%)
II (Index)	9	7	16 (25.4%)
III (Middle)	8	6	14 (22.2%)
IV (Ring)	9	3	12 (19.0%)
V (Little)	9	8	17 (27.0%)

Given the significant elevation of Arch patterns in the autistic group, an exploratory digit-wise analysis was conducted. As shown in Table 4, Arches were distributed across all fingers, with the highest frequencies observed on the Little (V; 27.0%) and Index (II; 25.4%) fingers, followed by the Middle (III; 22.2%) and Ring (IV; 19.0%) fingers. The Thumb (I) had the lowest frequency of Arches (6.3%).

DISCUSSION

This study provides novel, gender-stratified insights into the dermatoglyphic profiles of autistic children in Bangladesh. Our core finding of a significant increase in Arch and Radial Loop patterns, coupled with a decrease in Ulnar Loops in the autistic group, aligns with several international studies [13, 14, 19]. This triad of findings strengthens the proposition that atypical dermatoglyphic patterning is a tangible correlate of the altered neurodevelopmental trajectory in ASD, likely stemming from disturbances in ectodermal morphogenesis during the first trimester [5, 20]. The most striking finding is the divergent pattern between autistic males and females. Autistic males exhibited a broad increase across all variant patterns (Arch, Whorl, RL), consistent with the "male-shift" hypothesis observed in other minor physical anomalies [21]. In contrast, autistic females showed a highly specific and dramatic increase only in the Arch pattern. The complete absence of Radial Loops in autistic females in our sample is particularly intriguing and warrants replication in larger female cohorts. This sexual dimorphism in dermatoglyphic markers may reflect underlying differences in genetic vulnerability, hormonal influences on early brain-skin development, or a more severe genetic "hit" required for females to manifest autism, which could also be expressed in more pronounced physical stigmata [22, 23]. Our finding of a higher Arch frequency corroborates studies from Serbia, Nigeria, and Australia [14, 15, 19]. However, we found a higher Whorl frequency in autistic individuals, which contrasts with studies from Spain and Iran that reported lower Whorl counts [12, 24]. This discrepancy underscores the critical influence of ethnicity and population genetics on baseline dermatoglyphic patterns. The Bangladeshi population, with its unique genetic admixture, may express the neurodevelopmental "insult" of ASD through a specific dermatoglyphic signature, highlighting the necessity for population-specific normative data [17]. The bilateral symmetry of the pattern deviations (Table 3) suggests a systemic, developmentally early insult affecting both sides of the body equally, rather than a post-natal or localized event. The relatively even distribution of Arches across fingers (Table 4), with a slight preponderance on the 2nd and 5th digits, differs from studies that reported clustering on the 4th and 5th fingers [14, 25], again pointing to possible population-level variations. From a clinical perspective, dermatoglyphic analysis is non-invasive, rapid, and cost-effective. In resource-limited settings like Bangladesh, where access to advanced genetic testing and specialized developmental diagnostics is constrained, dermatoglyphics could be integrated as a simple, initial screening adjunct within a comprehensive diagnostic protocol. A high Arch count, especially in females, or the presence of Radial Loops in males, could raise the index of suspicion for ASD and prompt earlier referral for full assessment.

Limitations of The Study

This study has limitations, including a small sample size, particularly for autistic females (n=12), which limits the generalizability of gender-specific findings. The cross-sectional design prevents causal inferences, and we did not correlate dermatoglyphic patterns with ASD severity, cognitive ability, or genetic data. Future research should involve larger, multi-center cohorts, include familial dermatoglyphics for heritability assessment, and integrate genetic analyses to explore links between genomic variants and ectodermal patterning. Longitudinal studies could evaluate the predictive value of neonatal dermatoglyphics for later ASD diagnosis.

CONCLUSION

This study demonstrates significant and gender-dimorphic deviations in dermatoglyphic patterns among autistic children in Northern Bangladesh. The increased prevalence of Arch and Radial Loop patterns, manifesting differently in males and females, provides tangible evidence of altered early embryonic development in ASD. These findings contribute to the growing literature on physical biomarkers of autism and emphasize the importance of ethnic context in biomarker research. While not diagnostic on its own, dermatoglyphic analysis holds promise as a valuable, low-cost adjunctive tool in the multidisciplinary

assessment toolkit for ASD, potentially aiding in earlier identification and intervention, especially in underserved populations.

Declarations

- **Ethics Approval and Consent to Participate:** Approved by IERB, Rangpur Medical College. Informed consent/assent obtained.
- **Consent for Publication:** Not applicable.
- **Availability of Data and Materials:** The datasets used are available from the corresponding author on reasonable request.
- **Competing Interests:** The authors declare no competing interests.
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