Dermatoglyphics findings in Children with Intellectual Disability

by Ziske Maritska

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Original Article

Dermatoglyphics Findings in Intellectual Disability Children with Down Syndrome, Autism Spectrum Disorder and Attention-Deficit Hyperactivity Disorder: A Descriptive Cross-Sectional Study

Astri Anindya Sariza[1], Ziske Maristka[2], Lusia Hayati[2], Rara Inggarsih[2], Septi Purnamasari[2]

[1]Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia, [2]Department of Biology Medicine, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

Abstract

Introduction: Intellectual disability is a condition, in which mental development is incomplete or hindered, causing the individuals to encounter difficulties in everyday learning. Some of the conditions with intellectual disability can be seen in dermatoglyphics due to the same period formation between fingerprints and the neocortex. This study aims to evaluate the distribution of dermatoglyphics in intellectual disability individuals with Down syndrome, autism spectrum disorder (ASD) and attention-deficit hyperactivity disorder (ADHD). **Materials and Methods:** A descriptive study with a cross-sectional approach on children with intellectual disabilities diagnosed with Down syndrome, ASD and ADHD in a special needs school in Palembang. **Results:** Of all 86 respondents, 31 (36%) had Down syndrome, 30 (34.88%) had ASD and 25 (29.07%) had ADHD. The most commonly found fingerprint patterns in Down syndrome, ASD and ADHD were ulnar loop patterns (80.96%, 59.67% and 46.8%, respectively). The mean pattern Intensity Index values were 11.03 for Down syndrome, 13.06 for ASD and 14.36 for ADHD. The mean Dankmeijer Index values were 3.57 in Down syndrome, 12.07 in ASD and 16 in ADHD. The mean Furuhata Index values were 18.72 in Down syndrome, 107.29 in ASD and 146.22 in ADHD. The angle of axial triradius digital in Down syndrome, ASD and ADHD was mostly on the right and left palm: 3°–65°. **Conclusions:** The majority of intellectual disability individuals with Down syndrome, ASD and ADHD shared relatively the same dermatoglyphic findings, especially in the fingerprint pattern, yet show differences in some measurements.

Keywords: Attention-deficit hyperactivity disorder, autism spectrum disorder, dermatoglyphics, Down syndrome, intellectual disability

Introduction

Dermatoglyphics is the scientific study of fingerprints from the hands, fingers, soles of the feet and toes.[1] The fingerprint pattern is affected by many genes and the prenatal environment, and it will not change but only increase in size.[2]

Fingerprints are formed over 12–19 prenatal weeks, during which the neocortex develops over the same period.[2] The neocortex is the centre of intelligence and cognitive function;[3] both fingerprints and neocortex are affected by genetic factors.[4,5] Therefore, someone who has an inherited disease, mainly if it is caused by chromosomal aberrations such as Down's syndrome, will have a different dermatoglyphic pattern from normal people.[6,7]

Intellectual disability is a condition, in which the mental development is incomplete or hindered that causes the children to encounter difficulties in everyday learning.[8] This intellectual disability is often accompanied by genetic disorders such as Down's syndrome, autism spectrum

Address for correspondence: Dr. Ziske Maristka, Jl. Darmapala Number 58, Palembang City 30139, South Sumatera, Indonesia.
E-mail: ziske_maritska@unsri.ac.id

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disorder (ASD) or attention-deficit hyperactivity disorder (ADHD).[9-11] Based on national health interview survey data during 2014–2016, children aged 3–17 years with intellectual disabilities have increased from 5.76% to 6.99%.[12]

Studies also show that fingerprint patterns can be associated with embryonic development. Genetic analysis shows that the embryonic nerve is involved in the development of fingerprints. Therefore, observation of fingerprint patterns becomes something that can be used to understand the potential of certain individuals. One of the things that can be ascertained in the relationship between fingerprint patterns and embryonic nerves is the skills of interpersonal relationships, the ability of individuals to progress in terms of progress, and the possibility of individuals managing their emotions effectively.[13] Meanwhile, people with intellectual disabilities in particular such as Down syndrome, ASD and ADHD have disorders in these aspects. This shows that dermatoglyphics can be used as an effective measurement in assessing the intellectual property of each individual.[14]

Given this condition's complexity, which can further hinder the development of children in the future, children with intellectual disabilities with or without other genetic disorders must be detected as early as possible to get proper treatment and education from the start. The present study is planned to evaluate dermatoglyphics' distribution in intellectual disability with Down syndrome, ASD and ADHD that later could support research on dermatoglyphics as early detection for genetic diseases.

Materials and Methods

This study is a descriptive observational study with the cross-sectional approach, carried out at Karya Ibu Special School Palembang, Indonesia, from 28 September 2020 to 28 October 2020. Ethical clearance was obtained from the Research Ethics Committee of The Sriwijaya University Faculty of Medicine, Palembang, Indonesia (Protocol Number: 009–2020). Inform consent collected from parents by an agreement sheet and verbal approval from the child. A total of 86 students that met the inclusion criteria were enrolled in this study using the convenience sampling technique, i.e. 31 students with Down syndrome, 30 students with ASD and 25 students with ADHD.

Inclusion criteria

- ≤18 years old
- Experience one of the conditions; Down syndrome, ASD and ADHD
- Parents are willing and signed informed consent.

Exclusion criteria

- Deformity on one or more fingers
- Respondent does not have upper limbs.

The finger and palm print were collected and analysed following the procedure mentioned here.

First step: Recording finger and palm prints

The recording finger and palm print procedure were adopted by the Modified Purvis-Smith ink method.[15] Students were asked to clean their hands with a hand sanitiser. The whole process was supervised and guided by the research team, helping the students to press their fingers and palms against the ink stamp pads on the right and left hands before pressed against the white paper.

Second step: Respondent characteristic data

The records were taken anonymously. The only data obtained were age, sex, IQ level and genetic conditions. Age would be divided according to the National Institute of Child Health and Human Development Pediatric Terminology and IQ level divided according to Diagnostic and Statistical Manual of Mental Disorder IV criteria.[16,17]

Third step: Analysis of finger and palm prints

In this study, a qualitative examination and a quantitative examination were carried out. The qualitative examination includes assessing the fingerprint pattern with standard types, either as an arch, ulnar loop, radial loop or whorl with the help of a lens or by the naked eye. In contrast, the quantitative examination consists of the Axial Triradius Digital (ATD) angle, as well as the Pattern Intensity Index (PII), Dankmeijer Index (DI) and the Furuhata Index (FI), which is calculated using the formula:

1. PII[18]

$$PII = \frac{2\,xWhorl + Loop}{n}$$

n = the total number of subjects

2. DI[19,20]

$$\mathrm{DI} = \frac{Arch}{Whorl} x100\%$$

3. FI[20,21]

$$\mathrm{FI} = \frac{Whorl}{Loop} x100\%$$

Fourth step: Statistical analysis

The finger and palm print data were evaluated using IBM® Corp Statistical Package for the Social Sciences (SPSS®) for Windows, Version 26.0. Armonk, New York. The parameters analysed were the pattern, index and ATD angle frequency on each genetic condition's right and left hands.

Results

The baseline respondents' characteristics of 86 responded that genetic conditions and intelligence quotient level are presented in Table 1. Most respondents were 12–18 years old (52.3%) and 58.1% were male. The majority of cases had Down syndrome (36%), which was more than ASD (34.9%) and ADHD (29.1%). The respondents' most IQ level is the mild category with range: 50–69 (48.8%). Table 2 shows the

highest pattern in intellectual disability, i.e., the ulnar loop pattern, amounting to 548 fingers (63.7%), followed by a whorl (29.2%), radial loop (5%) and arch pattern (2.1%).

The distribution of the fingerprint patterns in each genetic condition can be seen in Tables 3 and 4. Down syndrome had a high incidence of ulnar loop patterns in almost all fingers (the thumb, index and middle finger of the right and left hand), whereas ADHD had a high incidence of whorl (80%) in the ring finger of the right hand. Down syndrome and ASD group had the most ulnar loop patterns, while ADHD had the most whorl pattern in the left-hand index and ring finger [Table 4]. In contrast, ASD and ADHD groups had the most whorl pattern in the right-hand index and ring finger [Table 3]. Down syndrome, ASD and ADHD had the most ulnar loop pattern in the thumb, middle and little finger of the right and left hand [Tables 3 and 4], but in the middle finger of the right hand, the ADHD group had the same proportion of ulnar loop and whorl patterns.

The index of fingerprint patterns can be seen in Tables 5 and 6. In this study, it was found that several respondents who had DI and FI values of infinite were excluded in this study. In Table 5 for intellectual disability, PII was obtained with a mean of 12.71, DI with a mean of 10.37 and FI with a mean of 86.19. Based on the genetic condition in Table 6, for PII in ADHD, the mean was 14.36, as against a mean of 13.06 for ASD and 11.03 for Down syndrome. The highest mean for DI was the ADHD group at 16, followed by ASD at 12.07 and Down syndrome at 3.57. On FI, the highest mean was ADHD with 146.22, followed by ASD at 107.29 and the Down syndrome group at 18.72. Tables 7 and 8 reveal the most angles in intellectual disability, and all the three genetic conditions are the same on the right and left hand; 30°–65°.

Table 1: Baseline respondent's characteristics, underlying genetic conditions and intelligence quotient level

Respondent's characteristics	*n* (%)
Age (years)	
Early childhood (2-5)	0
Middle childhood (6-11)	41 (47.7)
Early adolescence (12-18)	45 (52.3)
Sex	
Male	50 (58.1)
Female	36 (41.9)
Genetic conditions	
Down syndrome	31 (36.0)
Autism spectrum disorder	30 (34.9)
Attention-deficit hyperactivity disorder	25 (29.1)
IQ level	
Mild (50-69)	42 (48.8)
Moderate (36-49)	37 (43.0)
Severe (20-35)	7 (8.1)
Profound (<20)	0
Total	86 (100)

IQ: Intelligence quotient

Discussion

Our study shows similarities between intellectual disability with Down syndrome, ASD and ADHD compared to dermatoglyphics in ordinary people. The previous studies found the most extensive fingerprint pattern in ordinary people is the loop pattern (60%–70%), followed by the whorl pattern (25%–35%) and the arch pattern (5%).[22] Similarly, the previous study found that ASD had the most ulnar loop pattern.[23] Research also found that Down syndrome had a lower whorl pattern, and almost every finger has a higher percentage of ulnar loop pattern, especially the index finger.[24] In contrast, we also found that ADHD shows an increase in whorl pattern and decreased ulnar loop pattern compared to dermatoglyphic studies in ordinary people. Morgan *et al*. found that the most hyperactive children's pattern is the ulnar loop, but they had a higher percentage of whorl patterns and a lower percentage of ulnar loop patterns than controls.[25] Interestingly, in this study, it was found that ADHD experienced an increased incidence of whorl pattern, especially on the right-hand ring finger, thereby reducing the percentage of ulnar loop patterns compared to ordinary people.

Cho has found that generally, ordinary people's standard index value is ≥14 for PII, ≤10 for DI and ≥0 for FI.[26] Compared with standard values, Down syndrome and ASD had a slight decrease in the mean PII, whereas the mean PII value for ADHD was average. We also found the mean values of FI for ASD and ADHD had average values, whereas, in Down syndrome, it is decreased. This happens because almost all fingers in Down syndrome have a high incidence of the ulnar loop, and nine of the respondents had a loop pattern on their ten fingers, which could cause a slight decrease in the PII value and shallow FI values. This study shows the same results as research conducted by Shiono *et al*. that people with Down syndrome have a higher percentage five times of ulnar loop pattern on all ten fingers than controls, and they also had an increase in the frequency of the ulnar loop pattern along with a

Table 2: Frequency distribution of fingerprint patterns in intellectual disabilities

Fingerprint pattern	Right fingers					Left fingers					*n* (%)
	I	II	III	IV	V	I	II	III	IV	V	
Arch	0	6	1	1	1	0	4	2	2	1	18 (2.1)
Ulnar loop	59	46	61	36	57	60	51	67	48	63	548 (63.7)
Radial loop	3	9	3	4	4	4	5	2	1	8	43 (5)
Whorl	24	25	21	45	24	22	26	15	35	14	251 (29.2)
Total	86	86	86	86	86	86	86	86	86	86	860 (100)

Table 3: Percentage distribution of fingerprint pattern frequency in each genetic condition - Digiti Dextra

Grup	Finger	W (%)	UL (%)	RL (%)	A (%)	Sequence
DS	I	16.1	80.6	3.2	0	UL > W > RL > A
ASD		23.3	70	6.7	0	UL > W > RL > A
ADHD		48	52	0	0	UL > W > RL=A
DS	II	6.6	87.1	3.2	3.2	UL > W > RL=A
ASD		43.3	33.3	13.3	10	W > UL > RL > A
ADHD		40	36	16	8	W > UL > RL > A
DS	III	6.5	87.1	6.5	0	UL > W=RL > A
ASD		23.3	73.3	0	3.3	UL > W > A > RL
ADHD		48	48	4	0	UL=W > RL > A
DS	IV	22.6	64.5	9.7	3.2	UL > W > RL > A
ASD		60	36.7	3.3	0	W > UL > RL > A
ADHD		80	20	0	0	W > UL > RL=A
DS	V	12.9	77.4	9.7	0	UL > W > RL > A
ASD		30	66.7	3.3	0	UL > W > RL > A
ADHD		44	52	0	4	UL > W > A > RL

DS: Down syndrome, ASD: Autism spectrum disorder, ADHD: Attention-deficit hyperactivity disorder, W: Whorl, UL: Ulnar loop, RL: Radial loop, A: Arch

Table 4: Distribution of percentage of fingerprint pattern frequency in each genetic condition - Digiti Sinistra

Group	Finger	W (%)	UL (%)	RL (%)	A (%)	Sequence
DS	I	12.9	87.1	0	0	UL > W > RL=A
ASD		30	63.3	6.7	0	UL > W > RL > A
ADHD		36	56	8	0	UL > W > RL > A
DS	II	3.2	90.3	3.2	3.2	UL > W=RL=A
ASD		40	46.7	6.7	6.7	UL > W > RL=A
ADHD		56	32	8	4	W > UL > RL > A
DS	III	0	96.8	0	3.2	UL > A > W=RL
ASD		26.7	70	3.3	0	UL > W > RL > A
ADHD		28	64	4	4	UL > W > RL=A
DS	IV	29	67.7	0	3.2	UL > W > A > RL
ASD		40	60	0	0	UL > W > RL=A
ADHD		56	36	4	4	W > UL > RL=A
DS	V	12.9	71	16.1	0	UL > RL > W > A
ASD		20	76.7	0	3.3	UL > W > A > RL
ADHD		16	72	12	0	UL > W > RL > A

DS: Down syndrome, ASD: Autism spectrum disorder, ADHD: Attention-deficit hyperactivity disorder, W: Whorl, UL: Ulnar loop, RL: Radial loop, A: Arch

Table 5: Index of fingerprint patterns in intellectual disability

Index	*n*	Mean±SD	Median (minimum-maximum)
PII	86	12.71±3.01	12 (7-20)
DI	82	10.37±39.67	0 (0-300)
FI	84	86.19±162.58	25 (0-900)

PII: Pattern intensity index, DI: Dankmeijer index, FI: Furuhata index, SD: Standard deviation

decrease in the whorl and arch pattern.[27] In contrast, there were no ADHD students who had a loop pattern on their ten fingers, and ADHD has a higher whorl pattern than the average person.

Meanwhile, we cannot say that the dominance of the loop pattern on ASD is strong enough. Although the PII value on ASD is a little low, the FI value is still average. Like the normal PII and FI values in ADHD, ASD and ADHD still have some individuals who have a dominant whorl pattern, thereby increasing the mean FI value and ASD only has a slight decrease in the PII value due to some fingers still have a dominant ulnar loop pattern. There was also a slight increase in DI from all genetic conditions. These results are the same as Vashist *et al.*, which states that the DI value in people with mental retardation is higher than usual.[28] However, the increase that occurred was not too high, presumably due to many DI values of 0; indicates many individuals had no arch pattern at all but still has a whorl pattern. Although based on Dankmeijer's study, the DI values were higher in women; presumably, the slight increase of DI in our study was due to the predominantly male gender.[19] According to Wijerathne *et al.*, research that the DI value is higher for males than females.[20]

Table 6: Index of fingerprint patterns in each genetic condition

Group	Index	*n*	Mean±SD	Median (minimum-maximum)
DS	PII	31	11.03±1.7	11 (8-16)
ASD		30	13.06±3.49	12 (7-20)
ADHD		25	14.36±2.66	14 (8-19)
DS	DI	28	3.57±18.9	0 (0-100)
ASD		29	12.07±31.78	0 (0-100)
ADHD		25	16±60.33	0 (0-300)
DS	FI	31	18.72±31.6	11.11 (0-150)
ASD		28	107.29±196.57	25 (0-900)
ADHD		25	146.22±191.17	100 (11.11-900)

PII: Pattern intensity index, DI: Dankmeijer index, FI: Furuhata index, SD: Standard deviation, DS: Down syndrome, ASD: Autism spectrum disorder, ADHD: Attention-deficit hyperactivity disorder

Table 7: Frequency distribution of axial triradius digital angle in intellectual disability

Angle (°)	Left palm, *n* (%)	Right palm, *n* (%)
<30	1 (1.2)	0
30-65	82 (95.3)	82 (95.3)
>65	3 (3.5)	4 (4.7)
Total	86 (100)	86 (100)

Table 8: Distribution of percentage frequency of axial triradius digital angle in each genetic condition

Group	Palm	<30° (%)	30°-65° (%)	>65° (%)
DS	Right	0	90.3	9.7
ASD		0	100	0
ADHD		0	96	4
DS	Left	0	90.3	9.7
ASD		3.3	96.7	0
ADHD		0	100	0

DS: Down syndrome, ASD: Autism spectrum disorder, ADHD: Attention-deficit hyperactivity disorder

The size of the ATD angle of a person, in general, is 30°–65°.[29] The previous study of Morgan *et al*. found the mean of ATD angles in ADHD was 48.6° for the left palm and 48.4° for the right palm.[25] Besides that, Stošljević found the mean ATD angle in ASD is around 40°–50°.[23] In our study, the most common angles in intellectual disability with ASD and ADHD are similar to previous studies and angles in regular people, i.e., 30°–65°. The previous research found the ATD angle of Down syndrome is more expansive than usual.[30] The differences between previous studies and results in Down syndrome can be due to the ATD angle examination's weakness. It is affected by the respondent's age, which tends to change with the tendrils' size, the shape of the palms and the distance between the fingers and the pressure on the respondent's palm during the process.

There are the some limitations of this study. The racial and ethnic backgrounds, the severity of the intellectual disability and parental factors, especially mothers, are not generalised, which can also lead to significant differences in each individual's genetic background.

Although dermatoglyphics are currently being investigated as a non-invasive alternative to detecting intellectual disabilities, several studies have examined its opportunities. One of them is the study from Kiran *et al*. that found it related to the increasing frequency of loops and simian crease in intellectual disabilities,[31] but this research is still conducted in a small scope. It can be done in extensive and wide-scale research on the possibility of dermatoglyphics as early detection of intellectual disability, or at least it can strengthen the diagnosis that will be made.

Conclusions

The most children who are intellectually disabled and suffered from Down syndrome, ASD and ADHD have ulnar loop patterns. Intellectual disability individuals with Down syndrome had a decrease in the FI value, i.e. the ulnar loop pattern is higher, and the whorl pattern is lower than ordinary people with the discovery of nine individuals who had a loop pattern in the ten fingers. ADHD individuals have an increased incidence of whorl pattern in the right-hand ring finger, whereas Down syndrome has a high incidence of ulnar loop pattern almost in all fingers. Furthermore, the angles of ATD Down syndrome, ASD and ADHD are in the average person's value range: 30°–65°. This shows that the majority of intellectual disability individuals with these three conditions shared relatively the same dermatoglyphic findings yet also show differences in some measurements, implying varied pathways.

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Conflicts of interest

There are no conflicts of interest.

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