

Dermatoglyphic Patterns in Undergraduate Medical Students and their Association with Academic Performance: A Cross-sectional Study

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ABSTRACT

Introduction: Dermatoglyphics is the study of fingerprint patterns, which are unique to each individual and remain unchanged after birth. It has been used in criminology for decades. In recent years, its role in screening various medical conditions has been established. Dermatoglyphics has also been associated with cognitive ability, making it a potential predictor of academic potential.

Aim: To investigate the association between dermatoglyphic patterns and the academic performance of medical students.

Materials and Methods: A cross-sectional study was conducted in the Department of Anatomy, Jawaharlal Nehru Medical College, Wardha, Maharashtra, India on 200 undergraduate medical students (94 males and 106 females) from January 2019 to December 2020. Fingerprint patterns were obtained using the standard ink method. The parameters studied included arches, loops, whorls, composites, Total Finger Ridge Count (TFRC), and the 'atd' angle. The academic performance of participants was assessed based on the marks obtained in the National Eligibility Cum Entrance Test (NEET) and the overall marks scored in the first-year university examination. Statistical analysis involved the

use of arithmetic mean, standard deviation, Chi-square test, and one-way Analysis of Variance (ANOVA).

Results: In present study, the most common fingerprint pattern in the right hand was an arch (30.9%), followed by a whorl (24.5%). In the left hand, the most common fingerprint pattern was a whorl (40.6%), followed by an ulnar loop (20.1%), with no gender difference observed. Thumb, index finger, middle finger, ring finger, and little finger exhibited different fingerprint patterns between the right and left hand, indicating asymmetry. This asymmetry was associated with lower academic performance. Higher academic performers in the NEET had a higher frequency of whorls and composites. TFRC showed no association with academic performance. Students with an 'atd' angle between 41 and 50° demonstrated higher academic performance.

Conclusion: The present study found that asymmetry of fingerprint patterns and a higher 'atd' angle ($\geq 51^\circ$) were correlated with lower academic performance among medical students. These findings suggest potential directions for early academic intervention, provided multicentric studies are conducted in the future.

Keywords: Association, Fingerprint, Symmetry

INTRODUCTION

In 1823, Czech physiologist and biologist Joannes Evangelista Purkinje began studying the papillary ridges on the palms and soles [1]. Harold Cummins, an anatomist from Tulane University, coined the term 'dermatoglyphics,' which refers to the study of epidermal ridges and their various patterns. Humans, apes, and monkeys are characterised by prominent ridges on their volar skin, particularly on the palms and soles, which act as an anti-slip mechanism, useful for gripping and improving touch sensation [2].

An epidermal ridge pattern first appears on the mounds of the skin in the early months of intrauterine life. Different patterns of epidermal ridges can be observed on the fingertips, the four interdigital parts, and the thenar and hypothenar eminences of the palms and soles. However, during the third to fourth month of intrauterine life, the process of epidermal ridge formation begins, accompanied by a decrease in the size of the mounds, which concentrates the appearance of ridge patterns. If any hereditary or environmental factors disturb fetal growth during this period, it can cause modifications in the configuration of the epidermal ridge pattern. Once formed, these patterns do not alter except in size [3]. After birth, environmental factors do not significantly influence dermatoglyphic patterns [4].

Dermatoglyphics is a method used to obtain and study the impressions of the papillary ridges on the fingertips and palms. These ridges form narrow parallel or curved arrays, divided by narrow furrows. Ducts of the sweat glands are present along the top part of each ridge at regular intervals [5]. Undulation with ridges and furrows occurs beneath the epidermis around the 12th week of development [6,7]. Every individual has a unique fingerprint, as epidermal ridges are genetically determined and their specific pattern remains constant throughout life. This makes fingerprints diagnostically significant for genetic disorders as well as for personal identification. The inheritance of fingerprint patterns follows a polygenic pattern [8,9]. Scientific evidence suggests a close association between dermatoglyphic prints (fingerprints and palm prints) and brain functions, as the development of the brain and the epidermal ridges of the hand from embryonic ectoderm occur during the same period [10,11].

The cognitive capabilities of students, such as memory, speaking skills, and hearing skills, play a role in their learning and educational achievements [12,13]. These cognitive abilities are related to the features of the cerebral cortex [14]. Academic achievements also reflect the level of reasoning and understanding [15]. The student's academic brain activity is reflected in the qualitative and quantitative evaluation of their academic success [16,17].

Previous studies have suggested an association between specific dermatoglyphic patterns and intelligence as well as academic excellence [15-17]. The present study aimed to determine whether a specific dermatoglyphic trait exists and is associated with the NEET score and academic performance of medical students in university examinations.

MATERIALS AND METHODS

The present cross-sectional study was conducted on undergraduate medical students of Jawaharlal Nehru Medical College, Sawangi (Meghe), Wardha, in the Department of Anatomy for a period of two years, from January 2019 to December 2020. The study was approved by the Institutional Ethics Committee (DMIMS(DU)/IEC/JUN-2019/8042). Informed consent was obtained after explaining the details of the study, and participation was voluntary.

Inclusion criteria: First year Bachelor of Medicine and Bachelor of Surgery (MBBS) students.

Exclusion criteria: Students with skin diseases involving the palms and those with hand deformities were excluded from the study.

Sample size: The study was conducted on 200 (94 males and 106 females) first year MBBS students.

Study Procedure

The fingerprints of the right and left hand palms of 200 medical students were obtained using the standard ink method after obtaining consent from the participants. With the aid of magnifying hand lenses, these prints underwent extensive dermatoglyphic examination.

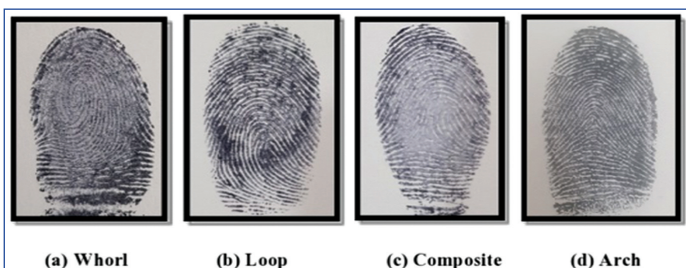
The parameters studied were:

Qualitative, namely:

- Arches
- Loop (Ulnar loop with or without a central pocket, and Radial loop with or without a central pocket)
- Whorl
- Composite [Table/Fig-1] and

Quantitative, namely:

- Total Finger Ridge Count (TFRC)
- 'atd' angle

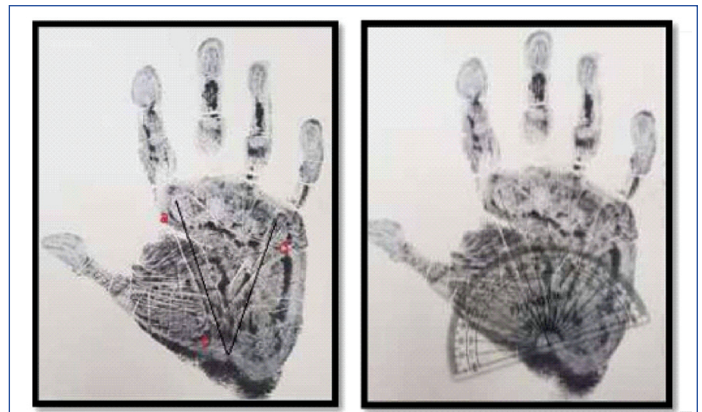


[Table/Fig-1]: Different finger print patterns.

The 'atd' angle is calculated by drawing a line from the digital tri-radius 'a' to the axial tri-radius 't' and from the digital tri-radius 't' to the digital tri-radius 'd', and measuring the angle [4]. The triradii a, b, c, and d are located just below the four digits of the hand, starting from the index finger to the smallest finger. The triradius T is found on the base of the palm between the hypothenar and thenar eminences [Table/Fig-2].

The parameters analysed to study the academic performance of the participants were the marks scored in NEET, which were obtained and verified from the NEET mark lists available with the students, and the overall marks scored in the first year university examination.

For the purpose of present study, NEET scores were categorised as follows: 115-300, 301-400, and 401-500. The scores for the university examination were categorised as <50, 50-60, and ≥61.



[Table/Fig-2]: 'atd' angle measurement in palmar dermatoglyphics.

STATISTICAL ANALYSIS

The statistical analysis was conducted using the arithmetic mean, Standard Deviation, Chi-square test, and one-way ANOVA. The analysis was performed using Statistical Packages for Social Sciences (SPSS) version 27.0 and GraphPad Prism version 7.0. A significance level of $p < 0.05$ was considered.

RESULTS

The study included 200 undergraduate medical students, consisting of 94 males and 106 females.

The most common fingerprint pattern in the right hand was arch (309, i.e., 30.9%), followed by whorl (245, i.e., 24.5%). In the left hand, the most common fingerprint pattern was whorl (406, i.e., 40.6%), followed by ulnar loop (201, i.e., 20.1%). Fingerprints of the thumb, index finger, middle finger, ring finger, and little finger showed asymmetry between the right and left hand [Table/Fig-3,4].

The analysis of the association between fingerprint patterns and marks scored in NEET revealed that higher academic performers had a higher frequency of whorls and composites in the thumb, while low performers had a higher frequency of loops and arches. This difference was statistically significant ($p < 0.05$). However, there was no statistically significant difference in the distribution of fingerprint patterns in the index, middle, ring, and little fingers between low and high scorers [Table/Fig-5].

The analysis of the association between fingerprint patterns and marks scored in the first year MBBS University examination showed no statistically significant difference, suggesting that fingerprint patterns are not associated with marks obtained in the university examination [Table/Fig-6]. There was no difference in TFRC between the right and left hand ($p = 0.58$) [Table/Fig-7], and no gender difference was observed in TFRC ($p = 0.22$) [Table/Fig-8].

There was no statistical difference in TFRC concerning marks scored in NEET or in the first year MBBS university examination [Table/Fig-9]. The mean 'atd' angle of the right hand was 45.55 ± 3.99 , and that of the left hand was 43.77 ± 3.5 . The total mean 'atd' angle was 44.66 ± 3.86 [Table/Fig-10]. The 'atd' angle in males was 44.73 ± 4.19 , and in females, it was 44.59 ± 3.56 . The difference between genders was statistically non significant [Table/Fig-11].

Significantly higher NEET scores were observed in students with an 'atd' angle between $41-50^\circ$ (p -value 0.001). Students with an 'atd' angle between 41 to 50° also scored the highest marks in the first year MBBS university examination, although this difference was statistically non significant (p -value 0.25) [Table/Fig-12].

DISCUSSION

In present study, it was observed that the most common fingerprint pattern in both male and female students' hands was whorl, followed by arch, composite, and loops.

Finger print pattern	Gender	Pattern							Total	χ^2 -value	p-value
		Ulnar loop with CP	Ulnar loop without CP	Radial loop with CP	Radial loop without CP	Composite	Whorl	Arch			
Thumb	Male	2	6	13	11	7	32	23	94	2.33	0.88, NS
	Female	1	4	16	11	10	32	32	106		
	Total	3	10	29	22	17	64	55	200		
Index	Male	1	9	5	6	22	28	23	94	12.91	0.04, S
	Female	0	11	9	7	15	18	46	106		
	Total	1	20	14	13	37	46	69	200		
Middle	Male	3	11	4	5	22	18	31	94	1.73	0.94, NS
	Female	2	11	6	8	22	25	32	106		
	Total	5	22	10	13	44	43	63	200		
Ring	Male	1	9	9	9	15	19	32	94	4.66	0.58, NS
	Female	1	6	8	11	27	25	28	106		
	Total	2	15	17	20	42	44	60	200		
Little	Male	3	11	9	18	11	18	24	94	10.46	0.10, NS
	Female	1	6	8	10	13	30	38	106		
	Total	4	17	17	28	24	48	62	200		

[Table/Fig-3]: Distribution of finger print pattern in male and female students in right hand.

Finger print pattern	Gender	Pattern							Total	χ^2 -value	p-value
		Ulnar loop with CP	Ulnar loop without CP	Radial loop with CP	Radial loop without CP	Composite	Whorl	Arch			
Thumb	Male	0	21	1	3	16	35	18	94	0.79	0.97, NS
	Female	0	23	2	3	15	44	19	106		
	Total	0	44	3	6	31	79	37	200		
Index	Male	0	14	2	3	19	40	16	94	2.53	0.77, NS
	Female	0	18	4	7	16	44	17	106		
	Total	0	32	6	10	35	84	33	200		
Middle	Male	0	13	2	3	16	49	11	94	2.36	0.79, NS
	Female	0	15	4	5	17	47	18	106		
	Total	0	28	6	8	33	96	29	200		
Ring	Male	0	14	1	11	16	47	5	94	15.86	0.007, S
	Female	0	17	7	3	24	40	15	106		
	Total	0	31	8	14	40	87	20	200		
Little	Male	0	14	1	11	16	47	5	94	15.86	0.007, S
	Female	0	17	7	3	24	40	15	106		
	Total	0	31	8	14	40	87	20	200		

[Table/Fig-4]: Distribution of finger print pattern in male and female students in left hand.

Finger	Marks	Ulnar loop	%	Radial loop	%	Composite	%	Whorl	%	Arch	%	Total	χ^2 -value
Thumb	115-300	14	25.00	10	17.86	2	3.57	13	23.21	17	30.36	56	16.26 p=0.039, S
	301-400	40	13.25	44	14.57	39	12.91	114	37.75	65	21.52	302	
	401-500	3	7.14	6	14.29	7	16.67	16	38.10	10	23.81	42	
Index	115-300	6	10.71	10	17.86	11	19.64	19	33.93	10	17.86	56	12.35 p=0.13, NS
	301-400	41	13.58	24	7.95	54	17.88	100	33.11	83	27.48	302	
	401-500	6	14.29	9	21.43	7	16.67	11	26.19	9	21.43	42	
Middle	115-300	6	10.71	9	16.07	9	16.07	17	30.36	15	26.79	56	7.68 p=0.46, NS
	301-400	44	14.57	25	8.28	56	18.54	110	36.42	67	22.19	302	
	401-500	5	11.90	3	7.14	12	28.57	12	28.57	10	23.81	42	
Ring	115-300	10	17.86	9	16.07	7	12.50	22	39.29	8	14.29	56	7.72 p=0.46, NS
	301-400	32	10.60	42	13.91	68	22.52	97	32.12	63	20.86	302	
	401-500	6	14.29	8	19.05	7	16.67	12	28.57	9	21.43	42	
Little	115-300	17	30.36	13	23.21	8	14.29	13	23.21	5	8.93	56	13.04 p=0.11, NS
	301-400	61	20.20	62	20.53	33	10.93	88	29.14	58	19.21	302	
	401-500	9	21.43	14	33.33	2	4.76	7	16.67	10	23.81	42	

[Table/Fig-5]: Association of marks scored in NEET with dermatoglyphic pattern.

Finger	Marks	Ulnar loop	%	Radial loop	%	Composite	%	Whorl	%	Arch	%	Total	χ ² -value
Thumb	<50	11	19.64	10	17.86	6	10.71	17	30.36	12	21.43	56	5.87 p=0.66, NS
	50-60	0	0	0	0	1	50.00	1	50.00	0	0	2	
	≥61	46	13.45	50	14.62	41	11.99	125	36.55	80	23.39	342	
Index	<50	3	5.36	2	3.57	13	23.21	21	37.50	17	30.36	56	11.18 p=0.19, NS
	50-60	0	0	0	0	1	50.00	0	0	1	50.00	2	
	≥61	50	14.62	41	11.99	58	16.96	109	31.87	84	24.56	342	
Middle	<50	10	17.86	7	12.50	11	19.64	17	30.36	11	19.64	56	3.76 p=0.87, NS
	50-60	0	0	0	0	0	0	1	50.00	1	50.00	2	
	≥61	45	13.16	30	8.77	66	19.30	121	35.38	80	23.39	342	
Ring	<50	9	16.07	11	19.64	12	21.43	18	32.14	6	10.71	56	8.77 p=0.36, NS
	50-60	0	0	1	50.00	1	50.00	0	0	0	0	2	
	≥61	39	11.40	47	13.74	69	20.18	113	33.04	74	21.64	342	
Little	<50	14	25.00	12	21.43	5	8.93	13	23.21	12	21.43	56	3.86 p=0.86, NS
	50-60	0	0	0	0	0	0	1	50.00	1	50.00	2	
	≥61	73	21.35	77	22.51	38	11.11	94	27.49	60	17.54	342	

[Table/Fig-6]: Association of marks scored in first year MBBS university examination and dermatoglyphic pattern.

TFRC	N	Mean	SD	Std. Error mean	t-value
Right	200	67.85	6.20	0.43	0.54 p=0.58, NS
Left	200	68.24	6.87	0.48	

[Table/Fig-7]: Comparison of Total Finger Ridge Count (TFRC) in right and left hand.

Gender	N	Mean	SD	Std. Error mean	t-value
Male	94	67.62	6.90	0.50	1.21 p=0.22, NS
Female	106	68.41	6.18	0.42	

[Table/Fig-8]: Gender-wise comparison of Total Finger Ridge Count (TFRC).
SD: Standard deviation

NEET marks	n	Mean TFRC	SD	F-value	p-value	University exam	N	Mean TFRC	SD	F-value	p-value
115-300	56	70.03	7.22	3.05	0.048, S	<50	56	69.46	7.77	1.53	0.21, NS
301-400	302	67.70	6.32			50-60	2	67.50	0.70		
401-500	42	67.85	6.81			≥61	342	67.81	6.31		
Total	400	68.04	6.54			Total	400	68.04	6.54		

[Table/Fig-9]: Association of marks scored in NEET and marks scored in first MBBS university examination against TFRC.

'atd' angle	N	Mean	SD	Std. Error	95% confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Right	200	45.55	3.99	0.28	44.99	46.10	31.00	59.00
Left	200	43.77	3.52	0.24	43.28	44.26	34.00	53.00
Total	400	44.66	3.86	0.19	44.28	45.04	31.00	59.00

[Table/Fig-10]: Comparison of 'atd' angle in right and left hand.

'atd' angle	Male	Female	t-value
Right	45.87±4.35	45.26±3.65	1.07, p=0.28, NS
Left	43.60±3.71	43.92±3.35	0.63, p=0.52, NS
Total	44.73±4.19	44.59±3.56	0.37, p=0.70, NS

[Table/Fig-11]: Gender-wise comparison of 'atd' angle in right and left hand.

'atd' Angle (degrees)	N	Marks scored in NEET				'atd' Angle (degrees)	N	Marks scored in first MBBS university examination			
		Mean	SD	F-value	p-value			Mean	SD	F-value	p-value
31-40	54	315.88	72.40	7.18	0.001, S	31-40	54	52.72	25.78	1.37	0.25, NS
41-50	327	329.30	60.21			41-50	327	56.13	22.00		
51-60	19	275.94	72.52			51-60	19	48.68	26.04		
Total	400	324.96	63.53			Total	400	55.32	22.76		

[Table/Fig-12]: Comparison of 'atd' angle with marks scored in NEET and in First MBBS university examination.
SD: Standard deviation

The most important finding in the present study was the absence of ulnar loops with central pockets in all fingers of the left hand in both genders. In the right hand, the fingerprint pattern of the index finger differed significantly between male and female students. Rastogi P et al., reported that the most common pattern in males was whorls, while loops were more common in females [18]. The results of the present study on fingerprint patterns were compared with various studies available in the literature [Table/Fig-13] [18-25].

Offei EB et al., and Atinga BE and Kiwaku OE, reported a symmetrical palm print pattern in their studies [26,27]. They also observed that this symmetrical pattern was associated with higher

academic performance. In present study, asymmetrical palm print patterns were observed among the students. However, authors did not find any association between symmetry and academic performance. Similar studies that report associations between different fingerprint patterns and academic performance have been tabulated in [Table/Fig-14] [23,28].

S. No.	Author's name and year	Place of study	Number of subjects	Parameters studied	Conclusion
1	Rastogi P [18] 2010	Mangaluru, India		Loops, whorls and arches	Commonest pattern in male was whorl and loops in females.
2	Bhavana D et al., [19] 2013	Dharwad, Karnataka, India	200	Loops, whorls and arches	The commonest pattern in males was whorl (57.09%) and loops in females (52.63%) followed by arches in both males and females.
3	Mehta AA and Mehta AA [20] 2015	Nagpur, Maharashtra, India	140	Loops, whorls, and arches	Highest percentage in males was loops (48.43%), followed by 42.71% whorls and arches (08.86%) which was same in females also with 59.71% loops and 7.86% arches. Highest preponderance of loops was present in middle and little finger of both males and females. Maximum whorls were seen in ring finger of males whereas arches were more in index finger of both male and females.
4	Narayana BL et al., [21] 2016	Tirupati, Kurnool, Andhra Pradesh, India	100	Loops, whorls, arches and composite	Frequency of loops were found to be higher in males (51.23%) compared to that of females (48.76%). Whorls and arches were seen higher in females compared to males. Composites showed equal incidence in both sexes.
5	Kakkeri SR and Attar H [22] 2017	Bijapur, Karnataka, India	120	Loops, whorls, arches	Highest frequency of whorls followed by loops and arches. The fingerprint pattern was symmetrical (Whorls (53.9%), Loops (21.5%) and Arches (19.6%).
6	Siddapur KR et al., [23] 2017	Tamil Nadu, India	137	Loop, whorl, arch and composite	Arch and composite were more frequent pattern and loops and whorls pattern were least.
7	Katwal B et al., [24] 2017	Jorpati, Kathmandu, Nepal	200	Loop, whorl, arch and composite	Commonest pattern to be loops (56.1%) followed by whorls (37.8%), arches (5.85%) and composite (0.25%) in both right and left hands among males and females.
8	Das N et al., [25] 2018	Tezpur, Assam, India	200	Loops, whorls and arches	In both male and females loop (52.3%) is the commonest finger print pattern followed by whorl pattern (42.2%). Prevalence of loop on little and middle fingers, ring fingers and thumb with whorl and index fingers with arches in both right and left hands.
9	Present study	Wardha, Maharashtra, India	200	Arches, loops, whorl, composite, Total Finger Ridge Count (TFRC) and 'atd' angle	Commonest pattern of finger print in right hand was arch (30.9%) followed by whorl (24.5%) whereas in left hand the commonest finger print pattern was whorl (40.6%) followed by ulnar loop (20.1%) with no gender difference. Preponderance of whorl on thumb of right hand and arches on index, middle and ring fingers whereas all the fingers of left hand had preponderance of whorl finger print pattern.

[Table/Fig-13]: Studies reporting fingerprint patterns in different populations [18-25].

S. No.	Author's name and year	Place of study	Number of subjects	Parameters studied	Conclusion
1	Siddapur KR [23] 2017	Tamil Nadu, India	137	Loop, whorl, arch and composite	Medical students with arch finger print pattern perform better.
2	Nayak SB et al., [28] 2017	Karnataka, India	143	Right thumb finger print pattern i.e., whorl, arch, radial loop, and ulnar loop	The medical students with ulnar loop pattern scored higher marks distinction and the students with whorl pattern scored low to average. Students with whorls were either in low or average scoring groups while students with ulnar loop pattern scored higher marks compared to others.
3	In the present study	Wardha, Maharashtra, India	200	Whorl, arch, radial loop with or without central pocket, ulnar loop with or without central pocket and composite	The higher academic performers had more frequency of whorl and composites whereas low performers had high frequency of loops and arches in thumb. The finger print pattern of other fingers did not show any association to performance in NEET examination. Could not substantiate association of finger print pattern to marks scored in First year university examination.

[Table/Fig-14]: Studies reporting association between different fingerprint patterns and academic performance [23,28].

The present study showed no statistically significant difference in TFRC between the right and left hands. Similar findings were reported by Prabhakaran M et al., while Jacob S et al., observed that the TFRC in the left hand is lower than the right hand [29,30]. In present study, no gender difference in TFRC was observed, which is consistent with the report of Prabhakaran M et al., [29]. However, Reddy GG et al., Moore RT, and Khadri SY and Goudar ES reported higher TFRC in

males than females [31-33]. On the other hand, Cummin H and Midlo C and Nayak VC et al., observed that TFRC was higher in females compared to males, which is in contrast to our study [34,35].

In the present study, no association was found between the TFRC and academic performance. Prabhakaran M et al., reported that the TFRC was highest in the intermediate intelligence group compared to the groups with high and low intelligence [29].

S. No.	Author's name and year	Place of study	Number of subjects	Parameters studied	Conclusion
1	Vashist M et al., [36] 2009	MD University, Rohtak, Haryana, India	1000 (500 normal individual and 500 mentally retarded individual)	'atd' angle	More than 75% normal individuals showed the 'atd' angle in the range of 35-40°, whereas only 4.2% individuals had above 55°. Lower range of average 'atd' angle (44.50) in normal individual.
2	Biswas S [37] 2011	Naxalbari region of Darjeeling district, the terai portion of sub-Himalayan West Bengal	202 (in equal proportions-101 male, 101 female)	Fingers and bilateral palmer prints	The atd angle for pooled data is 42.290 with 42.240 for male and 42.340 for female.
3	El-Sawwa EA and Mahfouz MM [38] 2017	Lebanon	100 (50 males and 50 females of Lebanese medical students)	Finger prints and bilateral palmer prints (atd angle)	No difference in 'atd' angle in right and left and also reported no gender difference. They reported mean 'atd' angles of 45 in both hands and for both sexes.

4	Ukoha UU et al., [39] 2019	Nigeria	400 students (200 males and 200 females)	A-B ridge count (ABRC) and ATD angle	The mean ATD angles in males were 43.07±4.99 (right palm) and 43.99±4.77 (left palm), while the mean ATD angles in females were 43.91±5.11 (right palms) and 44.05±5.12 (left palms). There was no statistically significant difference in the values of ATD angle between males and females.
5	Present study	Wardha, Maharashtra, India	200	Finger prints, palmer prints (TFRC and 'atd' angle)	The 'atd' angle in right and left hand ranged from 45±3.99, 43.77±3.52, respectively and overall mean of 'atd' angle in right and left hands was 44.66±3.86. No gender difference related to 'atd' angle.

[Table/Fig-15]: Studies Reporting "atd" in different populations [36-39].

In this study, no gender difference related to the 'atd' angle was noted. Studies reporting the 'atd' angle in different populations have been tabulated in [Table/Fig-15] [36-39]. In the present study, high academic performers in the NEET and first year MBBS university examinations had 'atd' angles between 41 to 50°. Moderate academic performers had 'atd' angles between 31 to 40°, while lower performers had 'atd' angles between 51 to 60°. Similar findings were reported by Atinga BE and Kwaku OE, and Cesarik M et al., [27,40]. However, Rishi R and Sharma A observed no association between the 'atd' angle and academic achievements [41].

Limitation(s)

The present study is a small-scale study conducted within a single Institute and did not compare the results with students from other Institutes.

CONCLUSION(S)

The findings of the present study suggest that there was no gender difference in fingerprint patterns. There was asymmetry between the right- and left-hand fingerprint patterns, which correlated with low academic performance. The 'atd' angle was found to be associated with academic performance, indicating that higher 'atd' angles ($\geq 51^\circ$) were associated with lower academic performance. However, large-scale multi-institutional studies are warranted to obtain robust data and establish it as a reliable tool for predicting academic performance. Such studies would help identify low performers and enable the initiation of necessary interventions at an early stage.

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