Evaluation of fingerprint pattern among students of Nobel Medical College, Biratnagar, Nepal

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ABSTRACT

Introduction: A fingerprint identification system can serve as the most convenient, reliable, and cost-effective method for accurate identification. This system of identification is based on the principle that the skin of the fingertips and the thumb have distinctive ridges whose arrangement and distribution remain unchanged throughout a person's life, and that no two individuals have identical patterns. So, the objective is to identify the pattern of fingerprints and their correlation with sex among students of Nobel Medical College.

Methods: A cross-sectional study was conducted in Nobel Medical College and Teaching Hospital, including 100 medical undergraduate students. Among them, 46 were females, and 54 were males. Fingerprints were taken on a white sheet of paper with the help of a stamp pad. All patterns were confirmed using a magnifying glass. Data analysis was done by using SPSS. Chi-square test of Independence was performed for each finger on the right and left hand.

Results: Loops were the predominant pattern across all digits, more frequent in males, particularly on the thumb (58.8%), middle (50.7%), and little (57.9%) fingers, while the whorl pattern was more frequent on the index (66.7%) and ring (58.1%) fingers. In fetmales, the composite pattern was more common on index (66.7%), middle (60.0%), and little (66.7%) fingers, while the arch pattern was more common on thumb (75%) and ting (66.7%) fingers. No significant association was found between the fingerprint pattern and the sex of the individual except in the index finger (p-value 0.001; chi-square test).

Conclusion: The findings of this study reveal the most common fingerprint pattern among the selected population, although it does not establish a clear association between the fingerprint pattern and the individual's sex, except for the index finger. In this case, composite patterns were more common in females, while whorl patterns were prevalent in males. This information could be useful for forensic medicine, anthropology, and genetics.

Keywords: Arch, composite, dermatoglyphics, fingerprint, gender difference, loop, whorl.

INTRODUCTION

In 1823, Joannes Evangelista Purkinje initiated the examination of the papillary ridges found on the palms and soles. Harold Cummins, an Anatomist from Tulane University, introduced the term 'Dermatoglyphics' which refers to the study of the patterns and ridges on the epidermis.[1] Humans, apes, and monkeys are distinguished by the volar skin ridges, which are noticeable in palms and soles.[2] In the early months of fetal development, epidermal ridge patterns on the skin's mounds aid in grip and enhance tactile sensation. Between the third and fourth month of intrauterine life, the formation of these ridges determines the size of the mound, which focuses the appearance of the pattern.[3]

During the fetal period, any hereditary or environmental factors that disrupt fetal growth can lead to changes in the configuration of epidermal ridge patterns. Once these patterns are established,

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DOI: https://doi.org/10.3126/dmj.v8i1

they remain constant except for their size.[4] The epidermis begins to show undulations of ridges and furrows around the 12th week of development. Each individual has a unique pattern because epidermal ridges are genetically determined.[5,6,7]

Dermatoglyphics holds significant value in forensic science because fingerprints remain unchanged throughout a person's life, even after death.[8] Fingerprints, the modern scientific exploration of the hand has established dermatoglyphics as a valuable tool for diagnosing psychological, metrical, metical, and genetic conditions.[9,10] Henry system classifies the fingerprint pattern as loop, whorl, arch, and composite.[11]

Dermatoglyphics has now been established as a valuable tool for identifying genetic diseases with a strong hereditary component, such as thalassemia, several carcinomas, psoriasis, leprosy, and vitiligo. Our research can be beneficial for society as it opens a new interdisciplinary collaboration between forensic science, genetics, anthropology, and AI research as well.[12] Despite the growing use of dermatoglyphics in forensic and anthropological research, there is limited literature explaining the relationship between the fingerprint patterns and the sex of individuals. Moreover, the available studies provide inconclusive findings, highlighting a clear research gap and the need for further investigation to better understand the potential association between fingerprint patterns and sexual dimorphism.

METHODS

This observational cross-sectional study was conducted in the Department of Anatomy, Nobel Medical College and Teaching Hospital during the period October 2024 - November 2025. Ethical approval was granted by the IRC of Nobel Medical College and Teaching Hospital (IRC-NMCTH Ref. no.61/2024). The study included 100 medical and dental undergraduate students. Fingerprints were collected according to the specified procedures. The materials utilized included an ink pad, A4-size paper, and a magnifying glass. Participants with deformities or scars on any of their any fingers resulting from injuries, congenital conditions, or diseases were excluded from this study. Before commencing this procedure, informed oral consent was obtained following a detailed explanation of the process to each participant. They were assured that their fingerprints would not be misused. Subjects were instructed to thoroughly wash and dry their hands. Subsequently, they were asked to press their fingers onto the inkpad and carefully roll them on an A4 sheet, where additional information such as name, sex, and age was also recorded. Participants were asked to avoid double rolling to prevent smudging of the prints. The dermatoglyphic patterns on the fingertips of both hands were examined using a magnifying glass.[11] The sample size was calculated as follows:

$$n = \frac{z^2 pq}{e^2}$$

where, e= margin of error 5%

Z=Z score for confidence; for 95% (1.96)

P= Proportion (Prevalence of outcome i.e. 0.5)

q=1-p

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.5)^2}$$

n= 384.16 = 384

For finite population we use

$$N_0 = \frac{n}{1 + \frac{n}{N}}$$

Where N=Known population
Hence, n=79.33
Thus, the sample size taken was 100.
A convenience sampling technique was used.
The data were collected and entered into Microsoft Excel (version), and analyzed using SPSS version 11.5. Descriptive statistics and an independent Chi -Square test were used as main statistical tools.

RESULTS

The data was collected from a total of 100 respondents. The gender distribution of the sample is as follows: Male respondents constitute the majority, representing 54% (n=54), and female respondents represent 46% (n=46) of the total sample. This indicates a relatively balanced gender representation in the study, with a slight majority of male participants. The distribution

provides an adequate base for comparing results across gender groups for the variables measured of the finger.

Figure 1: Distribution of gender

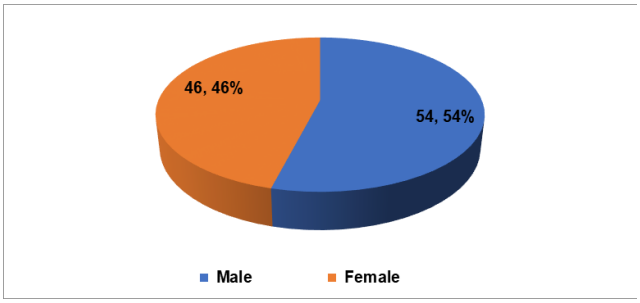

Table no. 1 showed that, analysis of fingerprint pattern distribution across all five digits revealed no statistically significant lateral asymmetry, with p-values for each finger thumb: p=0.358, index: p=0.665, middle: p=0.633, ring: p=0.297, little: p=0.211, despite some observed variations in pattern frequencies between right and left hands, such as composite patterns occurring more frequently on the right thumb (55.2%), index (58.3%), middle (55.6%), and ring fingers (60.0%) but more on the left little finger (60.0%), loop patterns showing near-equal distribution or slight asymmetries, arch patterns being absent on the right little finger while present on the left (100.0%), and whorl patterns demonstrating a perfect bilateral symmetry on the little finger (50.0% each side) but greater prevalence on the left for thumb (63.6%), index (55.9%), and middle fingers (61.5%).

Table no. 2, analysis of fingerprint patterns on the right hand revealed that while the loop pattern was the most prevalent overall, particularly on the thumb (30 males, 58.8%; 21 females, 41.2%), middle (34 males, 50.7%; 33 females, 49.3%), and little fingers (44 males, 57.9%; 32 females, 42.1%), notable gender-based distribution differences were observed across all digits; however, a statistically significant association between gender and pattern type was found exclusively for the index finger ($p < 0.001$), where composite patterns were more common in females (14, 66.7%) and whorl patterns were predominantly found in males (11, 73.3%). In contrast, despite variations such as the higher frequency of whorls on the ring finger (25 males, 58.1%; 18 females, 41.9%) and arches on

Table 1: Distribution of Fingerprint Pattern

Finger	Type	Right n (%)	Left n (%)	p-value (Chi-square test)
Thump	Composite	37 (55.2)	30 (44.8)	0.358
	Loop	51 (51.0)	49 (49.0)	
	Arch	4 (36.4)	7 (63.6)	
	Whorl	8 (36.4)	14 (63.6)	
Index	Composite	21 (58.3)	15 (41.7)	0.665
	Loop	46 (50.0)	46 (50.0)	
	Arch	18 (47.4)	20 (52.6)	
	Whorl	15 (44.1)	19 (55.9)	
Middle	Composite	10 (55.6)	8 (44.4)	0.633
	Loop	67 (51.1)	64 (48.9)	
	Arch	13 (52.0)	12 (48.0)	
	Whorl	10 (38.5)	16 (61.5)	
Ring	Composite	12 (60.0)	8 (40.0)	0.297
	Loop	42 (45.7)	50 (54.3)	
	Arch	3 (50.0)	3 (50.0)	
	Whorl	43 (52.4)	39 (47.6)	
Little	Composite	6 (40.0)	9 (60.0)	0.211
	Loop	76 (52.1)	70 (47.9)	
	Arch	0 (0.0)	3 (100.0)	
	Whorl	18 (50.0)	18 (50.0)	

Table 2: Frequency Distribution of Fingerprint Patterns on the Right Hand by Gender

Finger	Type	Male n (%)	Female n (%)	p-value (Chi-square test)
Thump	Composite	17 (45.9)	20 (54.1)	0.239
	Loop	30 (58.8)	21 (41.2)	
	Arch	1 (25.0)	3 (75.0)	
	Whorl	6 (75.0)	2 (25.0)	
Index	Composite	7 (33.3)	14 (66.7)	0.001
	Loop	27 (58.7)	19 (41.3)	
	Arch	9 (50.0)	9 (50.0)	
	Whorl	11 (73.3)	4 (26.7)	
Middle	Composite	4 (40.0)	6 (60.0)	0.345
	Loop	34 (50.7)	33 (49.3)	
	Arch	9 (69.2)	4 (30.8)	
	Whorl	7 (70.0)	3 (30.0)	
Ring	Composite	5 (41.7)	7 (58.3)	0.669
	Loop	23 (54.8)	19 (45.2)	
	Arch	1 (33.3)	2 (66.7)	
	Whorl	25 (58.1)	18 (41.9)	
Little	Composite	2 (33.3)	4 (66.7)	0.340
	Loop	44 (57.9)	32 (42.1)	
	Arch	0 (0.0)	0 (0.0)	
	Whorl	8 (44.4)	10 (55.6)	

Table 3: Frequency Distribution of Fingerprint Patterns on the Left Hand by Gender

Finger	Type	Male n (%)	Female n (%)	p-value (Chi-square test)
Thump	Composite	12 (40)	18 (60)	0.091
	Loop	31 (63.3)	18 (36.7)	
	Arch	2 (28.6)	5 (71.4)	
	Whorl	9 (64.3)	5 (35.7)	
Index	Composite	9 (60)	6 (40)	0.420
	Loop	28 (60.9)	18 (39.1)	
	Arch	9 (45)	11 (55)	
	Whorl	8 (42.1)	11 (57.9)	
Middle	Composite	3 (37.5)	5 (62.5)	0.498
	Loop	38 (59.4)	26 (40.6)	
	Arch	6 (50)	6 (50)	
	Whorl	7 (43.8)	9 (56.3)	
Ring	Composite	2 (25)	6 (75)	0.202
	Loop	31 (62)	19 (38)	
	Arch	1 (33.3)	2 (66.7)	
	Whorl	20 (51.3)	19 (48.7)	
Little	Composite	5 (55.6)	4 (44.4)	0.909
	Loop	38 (54.3)	32 (45.7)	
	Arch	1 (33.3)	2 (66.7)	
	Whorl	10 (55.6)	8 (44.4)	

the thumb (3 females, 75.0%; 1 male, 25.0%), the associations for the thumb (p = 0.239), middle finger (p = 0.345), ring finger (p = 0.669), and little finger (p = 0.340) did not reach statistical significance, indicating that fingerprint patterns on these digits are not strongly linked to gender in this study.

Table no. 3, analysis of fingerprint patterns across all five digits revealed no statistically significant associations with gender, with p-values ranging from 0.091 for the thumb to 0.909 for the little finger, indicating that gender was not a significant determinant of pattern type in this sample. Loops were the predominant pattern across all digits, consistently occurring more frequently in males, particularly on the thumb (63.3% male vs. 36.7% female), index (60.9% male), middle (59.4% male), ring (62% male), and little finger (54.3% male). Arches tended to show a female predominance, being notably more common in females on the thumb (71.4%) and little finger (66.7%), though overall numbers were low. Composite patterns were more frequent in females on most digits except the thumb, while whorls showed inconsistent gender distribution—more common in males on the thumb (64.3%) but slightly more frequent in females on the index, middle, and ring fingers. Despite these observed trends, the lack of statistical significance across all digits (thumb p = 0.0905, index p = 0.420, middle p = 0.498, ring p = 0.202, little finger p = 0.909) suggests that fingerprint patterns are not strongly differentiated by gender in this study population.

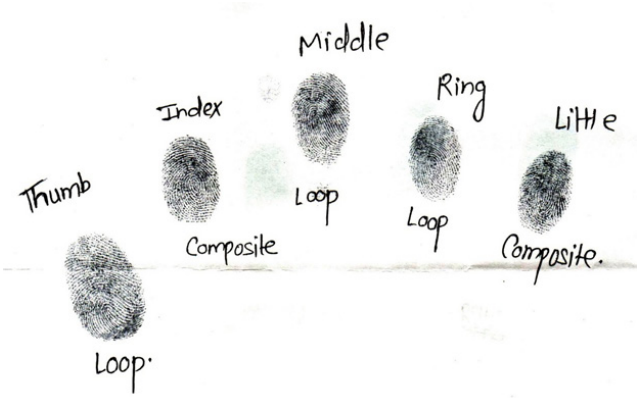

Fig 2.1: Different fingerprint patterns taken during our study.

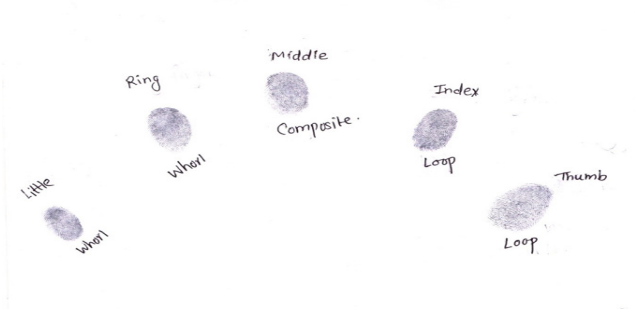

Fig 2.2: Different fingerprint patterns taken during our study.

DISCUSSION

The present study found that the loop was the most common pattern, particularly on the thumb, middle, and little fingers. A notable gender-based distribution was observed, where the composite pattern was found exclusively for the index finger in females and whorls predominantly in females. While comparing with each finger across the left and right hands, the composite pattern was the second most common pattern in the thumb and index finger. In a study conducted by Zahan A. et.al., various finger ridge patterns, including ulnar loop, whorl, and arch, and radial loop on the distal phalanges of hands, as well as total finger ridge count, were examined. It was observed that Male patients (cases) exhibited a significantly higher percentage of loop on the right hand, while both Radial loop and whorl patterns were more prevalent on the left hand. In female patients (case) the percentage of the arch pattern was significantly greater in both hands compared to the control group. The mean total finger ridge count was higher in both male and female case groups, respectively, compared to the control group.[12] Similar findings have been reported by Hirachan N. et. al., which stated the predominance of loops with (52.6%), followed by Whorl (39.4%), arches (7.3%), and composite (0.6%).[13] This finding does not align with another study conducted by Shrestha I. et al. In these studies, they have reported the highest number of arches. They also stated that the overall distribution of fingerprint patterns on both hands did not show a significant difference between males and females. Compared for gender predilection the report of our study analyzed that the distribution of fingerprint patterns of right hand (Composite, Loop, Arch and Whorl) across

different fingers (Thumb, Index, Middle, Ring and Little finger) and by gender (Male and female) revealed no statistically significant association between gender and fingerprint pattern for any of the five fingers in both left and right hand.[14] In the study conducted by Karki et.al., the frequency of loops was found to be higher in females (68.60%) than in males (35.80%), whereas whorls were more frequent in males (57.90%) as compared to females (27.10%).[15]

In another study conducted by Katwal B. et al., they found the fingerprint patterns on individual fingers showed predominantly loop on little and middle fingers, whorls on the ring finger and thumb, and arches on the index finger on both hands. This contradicts the findings of our study.[3] In the study conducted by Pradhan A et. al., an increased frequency of loop fingerprint 66 in right thumb and 62 in left thumb followed by whorl 53 in the right thumb and 50 in left thumb, followed by Arch 10 in right thumb and 18 in left thumb and the least composite 3 in right thumb and 2 in left thumb among 132 medical students.[5]

In a study conducted by Ghimire P. et al. involving 120 adults, the distribution of fingerprint patterns in the population was predominantly loops type (44.2%) followed by arches (30.8%), and whorls (25%). This result varies from our findings. Additionally, the study revealed that males had a higher occurrence of loop patterns (58.3%), while females predominantly exhibited arch patterns (55%). The Whorl pattern was more prevalent in males compared to females. Furthermore, there was a notable correlation between gender and fingerprint type, which was one of the unique findings of this study.[16]

In research led by Gupta A. et al., which was conducted in the North Indian population, the most prevalent fingerprint pattern of the right hand was loops, accounting for (53.3%) followed by whorls (38.2%), arches (6.7%), and composites (1.8%). The whorls were most commonly found in the ring finger, then the thumb, index, little, and middle fingers. In the thumbs and index fingers, whorls were more frequent in females than males. The loops were most prevalent in the little finger, followed by the middle, thumb, index, and ring fingers. In thumbs and index fingers, loops were more prevalent in males than in females. Arches were mostly found in the index, and a few were present in the middle, ring, thumb, and index fingers. In all digits, arches were more frequent in females than in males. The composites were most frequent in the index finger, followed by the middle, ring, thumb, and little finger. No gender variation was seen in the index and ring finger, but these were more prevalent in females than their male counterparts, in the middle and little finger. Only the thumb showed male dominance.[17]

In research by Chopra M. et al., the mean age for males was 35.78 years and for females 28. 52 years.The predominant pattern among both males and females was loop (62.8%) in males and (58.8%) in females, which was followed by whorl (24.53%) in males and (32%) in females, respectively. Amongst the loop patterns, the radial loop pattern was predominant in males (21.06%) and least common pattern was that of accidental loop (0.53%) where as in females the most predominate pattern amongst loop was that of ulnar loop (20.26%) as shown in table number 2. Plain whorl pattern was predominant in females (30.26%) as compared to males (23.73%). Whereas the plain arch pattern in males and females was 10.13% and 7.33%, respectively.[18]

CONCLUSION

The study reveals that loops are the most common fingerprint pattern among first-year medical and dental students at Nobel Medical College. Whorls follow, then arches; basically, the same distribution is seen worldwide. There were a few minor differences, like a higher number of arches in females, but the gender doesn't significantly affect fingerprint patterns. One might spot some small gender variations, but nothing substantial. It's important to remember that this data comes from a very specific population, i.e., medical and dental students only. To get a more accurate understanding of dermatoglyphic patterns, future research should include a wider variety of people and a larger sample size.

Funding: None.

Conflict of Interest: None.

Data availability statement: The data are available from the corresponding author upon request.

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