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CORRELATION OF FIRST DIGIT DACTYLOGRAPHY WITH RETINAL VASCULAR PATTERNS: AN OBSERVATIONAL STUDY.

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ABSTRACT
BACKGROUND
The retina is the only bodily area where the microvascular bed is visible, making it perfect for studying sequestration non-invasively in vivo and real life. Therefore, the present study was designed to find a correlation between 1st digit patterns with retinal vascular patterns.

MATERIALS & METHODS
The present study was conducted on 200 subjects. Digital photographs of the fundus of the eyes were taken with a fundus camera. Eyes were divided into superior and inferior quadrants on both the nasal and temporal sides of the eyes, then, the retinal vasculature was studied and analyzed. 1stdigit prints were taken and dermatoglyphic patterns were observed using a magnifying glass. Data obtained by studying retinal vascular patterns were compiled and findings were compared with 1st digit prints. Then, all the data so collected was recorded, tabulated, and analyzed.

RESULT
39% of subjects had loop patterns, 36.5% had whorls, and 1.5% had arches on their first digit. Retinal vasculature was more extensive on the temporal side in 87.5% of subjects. Subjects with loops on both thumbs had a higher mean number of branches in the superotemporal quadrant of the left eye (mean = 9.36, SD = 3.12), while those with whorls had more branches in the superotemporal quadrant of the right eye (mean = 9.34, SD = 2.87). These findings indicate a notable correlation between first-digit fingerprint patterns and retinal vascular branching.

CONCLUSION
This is the first published paper showing an important observation as both biometrics are genetically regulated. However, this correlation whether causal or effective cannot be explained as further research is needed and this data may provide a reference for future research.

RECOMMENDATIONS
Further research using advanced biometric tools is recommended to explore the causal relationship between fingerprint patterns and retinal vascular branching, potentially enhancing the efficacy of biometric identification methods.

Keywords: *Retina, Biometrics, Finger Prints, Temporal, Eye, Vasculature patterns*
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INTRODUCTION
Every human eye retina and fingerprint has its unique pattern and it is easily observed in its natural living state which plays a key role in biometrics and medical diagnosis [1]. Even identical twins do not share the same retinal and fingerprint pattern which makes them the best biometric characteristic in high-security environments [2,3].

Dermatoglyphics and retinal recognition are based on the principles that they are not changeable, thus- Individuality and Persistence [4]. Once formed these patterns do not change throughout life. For these amazing qualities, they are universally accepted in not only diagnostic and therapeutical tools but also emerging tools for person identification in biometrics [5, 6, 7]

The foundation of retinal recognition is the pattern of blood vessels present in the human retina as it is a highly stable pattern [8]. It is also highly accurate and one of the hardest biometrics to forge as the identification relies on the blood circulation along the vessels. Similarly, fingerprint-based recognition has been the longest-serving, most successful,

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and most popular method for person identification and as a predictor of various diseases [5, 9,10].
However, many studies have reported fingerprints and retinal imaging in the high biometrics category i.e. with a high accuracy rate and consistency. Any correlation between the two can increase the efficacy of their use as biometrics. Thus, this study has been conducted to find out a correlation if any between the first digit patterns and retinal vasculature patterns.

MATERIALS AND METHODS

Study design

An observational study.

Study setting

The study took place at MMIMSR (Mullana, Ambala).

Participants

The present study was conducted on 200 subjects aged 18 to 30 years.

Inclusion criteria

Healthy individuals without any Ophthalmic and related abnormalities were included.

Exclusion criteria

Individuals with missing and incomplete data were excluded.

Bias: There was a chance that bias would arise when the study first started, but it was avoided by giving all participants identical information and hiding the group allocation from the nurses who collected the data.

Procedure

The fundii of both eyes was photographed with a fundus camera [Zeiss Visucamlite] and digital photographs were taken (Figure 1, 2).

Fig 1: Fundus camera

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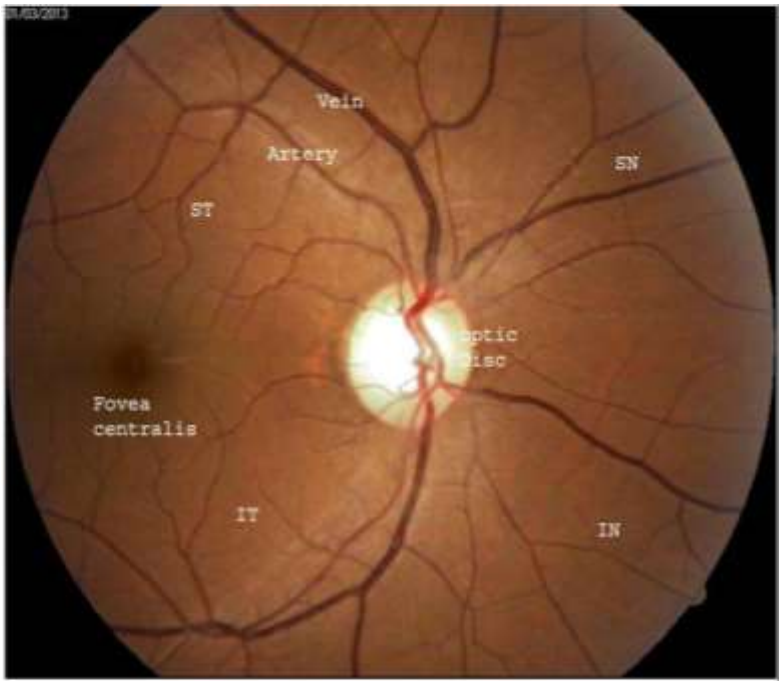

Fig 2: FUNDUS OF EYE

SN: Superonasal Quadrant
IN: Inferonasal Quadrant
ST: Superotemporal Quadrant
IT: Inferotemporal Quadrant

Eyes were divided into 4 quadrants:-

1. SuperoNasal
2. InferoNasal
3. SuperoTemporal
4. InferoTemporal

The retinal vasculature was studied and analyzed (Figure 3)

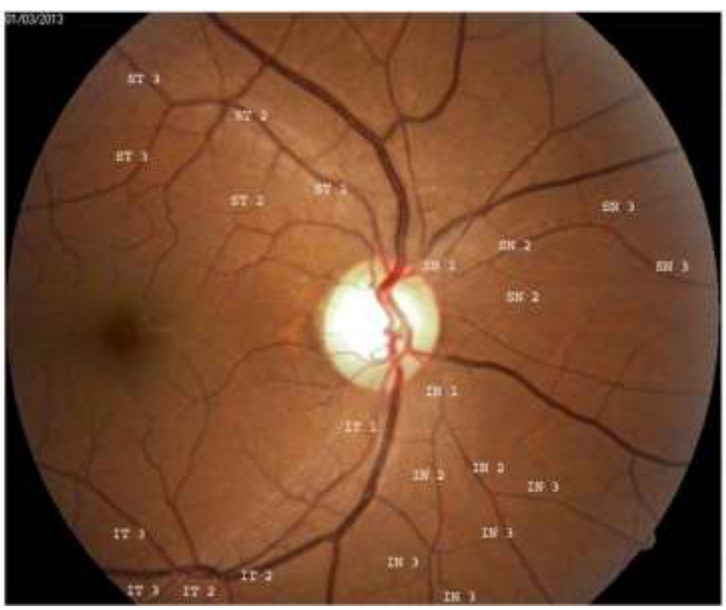

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Fig 3: Branching Pattern of Retinal Vasculature:

SN: Superonasal; **IN:** Inferonasal; **ST:** Superotemporal; **IT:** Inferotemporal
1: Primary Branch, **2:** Secondary Branch, **3:** Tertiary Branch

Branches were named as:
1. Primary Branches- Arteries that come out of the optic disc.
2. Secondary Branches- branches of the primary branches.
3. Tertiary Branches- branches of the secondary branches.

1st digit prints of both right and left thumb were taken with the stamp pad (inkpad). Then the prints were examined using a magnifying glass to look for Arches, Whorls, Radial Loops, and Ulnar Loops.

Statistical analysis

The data so obtained by studying retinal vascular patterns were also compiled. Findings were compared with 1st digit prints. Then, the data so collected was compiled, tabulated, and analyzed and the results were presented.

Ethical considerations

Prior informed consent, both in English as well as vernacular language, for the study was taken from the participants included in the study.

RESULTS

Table 1 A 1st digit pattern Total subjects 200		Table 1 B Retinal Vessel distribution in both eyes	
Subjects With both thumb loops	39% (78)	TEMPORAL VESSELS- 87.5%	NASAL VESSELS- 4%
Subjects With both thumbs Whorls	36.5% (73)		
Subjects With both thumb Arches	1.5% (3)		

Table 1A & 1B:1st Digit Pattern In Both Thumbs & Distribution Of Retinal Vessels In Both Eyes

Loops were present more frequently (39%) in both thumbs than other patterns followed by whorls and then arches (Table 1A)

Table 1B shows the distribution of temporal and nasal vessels in both the right and left eyes. Vasculature was higher on the temporal side in 87.5% of subjects in both eyes.

Parameters	Thumb	N	Mean	Std. Deviation	Minimum	Maximum	P-Value
Superior Temporal vessels	Right	78	9.14	2.91	5	17	0.6491
	Left		9.36	3.12	5	17	
Inferior Temporal vessels	Right	78	7.37	2.43	1	14	0.962
	Left		7.35	2.8	1	17	

Table 2 Comparison Between Temporal Quagrants(Both Loops)

Table 2 shows a comparison between branches of temporal arteries and thumbs having loop patterns in both thumbs. The supratemporal quadrant has more mean branches of arteries.

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Temporal vessels	Both Whorls	73	33.75	6.65	20	58	0.624
	Both Loops	78	33.22	6.72	20	50	
Nasal vessels	Both Whorls	73	31.56	8.27	12	52	0.849
	Both Loops	78	31.31	8.19	9	9	

Table 3 Comparison between Branching Patterns in Both Quadrants

Also, the temporal quadrant has more mean of branching arcade of arteries than the nasal (Table 3).

Parameters	Thumb	N	Mean	Std. Deviation	Minimum	Maximum	P-Value
Superior Temporal vessels	Right	73	9.34	2.87	5	17	0.862
	Left		9.26	2.67	5	17	
Inferior Temporal vessels	Right		7.68	3.42	1	17	0.668
	Left	73	7.47	2.4	1	12	

Table 4 Comparison between Temporal Quadrants (Both Whorls)

Subjects with whorls on both 1st digits had higher branching in the superotemporal quadrant of the right eye (Table 4).

DISCUSSION

The study explored the correlation between first-digit (thumb) fingerprint patterns and retinal vascular patterns in 200 healthy subjects aged 18 to 30 years. It was found that loops were the most prevalent fingerprint pattern, observed in 39% of the subjects. Whorls followed closely, being present in 36.5% of the subjects, while arches were the least common, appearing in only 1.5% of the subjects. This distribution indicates a higher genetic variability and commonality in loop and whorl patterns among the study population.

A substantial majority of 87.5% of participants showed more extensive vascular branching in the temporal half of both eyes about the distribution of retinal vasculature. On the other hand, only 4% of the individuals had less extensive vasculature on the nasal side. Because of the retina's physical structure and metabolic requirements, there may be a natural tendency for more sophisticated vasculature on the temporal side, as indicated by the asymmetry in retinal vascular branching.

Retinal vascular branching and fingerprint patterns were shown to be significantly correlated in the study. With an average of 9.36 branches (SD = 3.12) in the superotemporal quadrant of the left eye, subjects with loops on both thumbs had more retinal vascular branches than other subjects. Conversely, individuals who possessed whorls on both thumbs exhibited a higher average number of branches (SD = 2.87) in the right eye's superotemporal quadrant. Furthermore, the mean number of branches in the inferior temporal arteries for the right eye (7.37) and left eye (7.35) of participants with loop patterns was 2.80 (SD = 2.43).

The current investigation focuses on the retinal arteries' typical morphological characteristics in healthy participants. There aren't many studies that examine the vascular geometry of healthy individuals like Taarnhoj et al.'s [11] research in the medical literature. A study on Danish individuals revealed that genetic factors accounted for the majority of the variability in retinal blood vessel diameters and blood pressure in healthy young adults with normal blood pressure and blood glucose. Another investigation on a healthy Danish population found that there was a significant range in the tortuosity of the retinal arteries in these individuals, with genetic influence being the main

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driver, explaining 82% of the observed variation in tortuosity [12]. Based on increasing consecutive subdivisions of the arterial tree, the current study assessed the branching patterns of retinal arteries and found that temporal arteries branch more than nasal arteries (Table 1A, 3). The current data somewhat agree with the findings of Hasan et al. [13], who also noted that temporal arteries had more widespread branching.

Because the temporal retina is larger than the nasal retina and has a metabolically active macula, previous research has demonstrated that retinal blood flow is higher in the temporal than in the nasal retina [14]. This is likely because of the differential retinal vascular growth gradient.

In the current study, the superotemporal quadrant contains more branches in 62.5% of the participants. Ida Mann noted a similar supero-inferior asymmetry, which she attributed to a delay in the formation of the inferior retina[15].

In the current investigation, loops were more common in first-digit designs, followed by whorls and arches (Table 1A). The outcome is similar to the global percentage distribution [16].

The preceding retinal vascular pattern, when correlated with the first digit pattern, indicated that the temporal part of the right eye was where the retinal vasculature was more heavily branching. On the other hand, patients with whorls on both first digits exhibited more branching in the superotemporal quadrant of the right eye (Table 4), and those with loops on both first digits had a stronger branching pattern in the left eye (Table 2). It is impossible to explain these noteworthy findings given the lack of published research examining the relationship between first-digit patterns and retinal vasculature. Therefore, the goal of writing this work was to provide reference data for additional research.

These findings suggest a genetic linkage between fingerprint patterns and retinal vascular structure, indicating that both biometrics may be regulated by similar genetic factors. The higher branching in specific retinal quadrants corresponding to certain fingerprint patterns points to potential use in enhancing biometric identification methods. However, the study also highlights the need for further research using advanced biometric tools to delve deeper into the causal relationships and underlying genetic mechanisms.

Overall, the study provides valuable insights into the correlation between dermatoglyphics and retinal vascular patterns, suggesting that these biometric traits are genetically influenced. This correlation has significant implications for biometric identification and could pave the way for more reliable and accurate methods in the future. Further research is recommended to explore these findings in greater detail and to develop sophisticated biometric tools to fully understand the genetic basis of these correlations.

GENERALIZABILITY

The study's findings suggest a genetic correlation between fingerprint patterns and retinal vascular branching, potentially enhancing biometric identification methods. However, these results are based on a specific demographic (healthy individuals aged 18 to 30) from a single location. To generalize these findings, further research involving diverse populations and age groups is necessary. Advanced biometric tools in future studies could help confirm and expand these results across different demographics.

CONCLUSION

The present study concludes that branching is more extensive in the temporal half of the retina and the study group with loop patterns on both 1st digits have more branching in the superotemporal quadrant of the left eye, whereas, subjects with whorls patterns in both 1st digits have more vasculature in superotemporal quadrant of the right eye.

This is an important observation as both biometrics are genetically regulated. However, this correlation whether causal or effective cannot be explained with observations of the present study. Further research with sophisticated biometric gadgets may help in explaining this correlation.

Limitations

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

Recommendation

Further research using advanced biometric tools is recommended to explore the causal relationship between fingerprint patterns and retinal vascular branching, potentially enhancing the efficacy of biometric identification methods.

Acknowledgment

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List of abbreviations

MMIMSR - Maharishi Markandeshwar Institute of Medical Sciences and Research
SD - Standard Deviation
ST – Superotemporal
SN – Superonasal
IN – Inferonasal
IT – Inferotemporal

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Conflict of interest
The authors have no competing interests to declare.

Authors Contributions
Sween Walia: Data collection & analysis, manuscript preparation
Bhavna: Coordination & manuscript review
Shubhangi : Statistical analysis

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