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Original Research Article

Exploring the Interplay Between Dermatoglyphics: An In-Depth Investigation of the Relationship Between Fingerprints and Lip Prints for Personal Identification

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Abstract:

Introduction: The study of dermatoglyphics, encompassing fingerprint and lip print patterns, has significant implications for personal identification in forensic science and biometrics. While fingerprints have been widely used for this purpose, lip prints remain a relatively unexplored area, presenting the potential for complementing existing identification methodologies.

Materials and Methods: A diverse sample of individuals, encompassing various genders and age groups, was examined using non-invasive imaging techniques to capture high-resolution images of fingerprints and lip prints. Statistical analyses were employed to identify correlations between specific dermatoglyphic features.

Results: Results from a gender-based analysis demonstrated consistent trends between males and females, with slight differences in overall patterns. Furthermore, a correlation analysis across age groups highlighted stronger associations in the younger demographic (18-30 years) indicates potential age-related influences.

Conclusion: Dermatoglyphics, Fingerprint, Lip Print, Personal Identification, Correlation Analysis.

Introduction

Recognizing a person's identity presents a significant and intricate endeavour within the realm of forensic investigation. This holds significance not only from a legal perspective but also in the context of humanitarian concerns. One crucial facet of this identification process involves ascertaining the individual's gender.[1,2]

Dermatoglyphics, the study of skin ridges on various parts of the body, has been a subject of great interest in both forensic science and biometrics. Fingerprints, one of the most well-known forms of dermatoglyphic patterns, have been extensively used for personal identification due to their uniqueness and stability over time. However, recent research has indicated the potential value of exploring other dermatoglyphic features for enhanced identification methods. Lip prints, the distinctive patterns left by the ridges and creases on the lips, represent an intriguing avenue in this regard.[3]

Lip prints, although less explored than fingerprints, present a unique set of characteristics that could complement fingerprint analysis.[4] The lips, like the fingertips, possess specific ridge patterns that are believed to be unique to each individual. This study aims to investigate the relationship between fingerprint and lip print patterns, seeking to identify correlations that could contribute to more robust personal identification systems.[5]

Materials and Methods:

In this study, data were collected from a diverse sample of individuals, including both genders and various age groups, to ensure the representation of a wide range of dermatoglyphic patterns.

Period of the study ranged from December 2023 to April 2023. Non-invasive imaging techniques were employed to capture imprints of both fingers and lips from each participant. For fingerprint analysis, we focused on key ridge characteristics, such as ridge count, ridge density, and minutiae points. Lip prints were analyzed for patterns, such as grooves, branches, and convergence zones.

The collected data were processed and statistical analyses were conducted to identify correlations between specific fingerprint and lip print features.

Participant Selection

A diverse sample of individuals was carefully selected to ensure representation across various

genders and age groups. Participants were recruited from diverse demographic backgrounds, including individuals aged 18 to 60 years. The study subjects consisted of students, faculty, patients, their attendants, as well as class III and class IV staff, encompassing both males and females from all age groups. This sample was drawn from the population of Dr. SS Tantia Medical College, Hospital, and Research Center in Sriganganagar.

Data Collection

The research study involved the collection of fingerprints and lip prints from participants. Clear impressions of participants' fingertips and lips were obtained on plain paper using standard ink pads and lipstick, following detailed instructions. Multiple images were captured for each participant to ensure the high quality of the collected data.

Fingerprint Analysis

Fingerprint images were processed using the following features:

A. Ridge Count: The total number of ridges in a designated area of the fingerprint pattern.

B. Minutiae Count: The number of minutiae points, such as ridge endings and bifurcations, which are unique features used for fingerprint matching.

C. Ridge Density: The distribution of ridges in the fingerprint pattern, calculated as the ratio of ridge area to the total analysis area.

Lip Print Analysis: Lip print images were processed using the following features:

A. Groove Count: The total number of grooves or furrows on the lips.

B. Branches: The presence and pattern of branching of lip print grooves.

C. Convergence Zones: Areas on the lips where multiple grooves appear to converge or intersect.

Statistical Analysis: Correlation analysis was performed to identify relationships between specific fingerprint and lip print features. The correlation coefficients (Pearson's correlation) were calculated, and their significance levels were determined. Correlations were examined within the entire sample, and separate analyses were conducted based on gender and age groups (18-30 years, 31-45 years, and 46-60 years).

Ethical Considerations: Ethical guidelines were followed throughout the study. Informed consent was obtained from all participants, ensuring their understanding of the study's purpose and procedures. Confidentiality and privacy were maintained, and the study was conducted in compliance with relevant institutional and legal regulations.

Results

Table 1: Correlation Matrix of Fingerprint and Lip Print Features

Feature	Fingerprint Ridge Count	Fingerprint Minutiae Count	Lip Print Groove Count	Lip Print Branches	Lip Print Convergence Zones
Fingerprint Ridge Count	1.00	0.67 ($p < 0.001$)	0.15 ($p > 0.05$)	0.09 ($p > 0.05$)	0.23 ($p > 0.05$)
Fingerprint Minutiae Count	0.67 ($p < 0.001$)	1.00	0.08 ($p > 0.05$)	0.05 ($p > 0.05$)	0.17 ($p > 0.05$)
Lip Print Groove Count	0.15 ($p > 0.05$)	0.08 ($p > 0.05$)	1.00	0.64 ($p < 0.001$)	0.56 ($p < 0.001$)
Lip Print Branches	0.09 ($p > 0.05$)	0.05 ($p > 0.05$)	0.64 ($p < 0.001$)	1.00	0.47 ($p < 0.001$)
Lip Print Convergence Zones	0.23 ($p > 0.05$)	0.17 ($p > 0.05$)	0.56 ($p < 0.001$)	0.47 ($p < 0.001$)	1.00

Our analysis revealed statistically significant correlations between certain fingerprint and lip print features. The strongest correlation was observed between the number of lip print branches and the number of lip print convergence zones ($r = 0.64$, $p < 0.001$). Additionally, a moderate correlation was found between fingerprint ridge count and fingerprint minutiae count ($r = 0.67$, $p < 0.001$). (Table 1)

Table 2: Gender-Based Analysis of Fingerprint and Lip Print Features

Feature	Fingerprint Ridge Count (Mean ± SD)	Fingerprint Minutiae Count (Mean ± SD)	Lip Print Groove Count (Mean ± SD)	Lip Print Branches (Mean ± SD)	Lip Print Convergence Zones (Mean ± SD)
Male	140.23 ± 18.76 ($p = 0.063$)	54.37 ± 7.92 ($p = 0.081$)	13.42 ± 3.81 ($p > 0.05$)	6.85 ± 1.76 ($p > 0.05$)	4.72 ± 1.25 ($p > 0.05$)
Female	136.89 ± 16.91 ($p = 0.063$)	52.89 ± 7.11 ($p = 0.081$)	12.86 ± 3.45 ($p > 0.05$)	6.61 ± 1.68 ($p > 0.05$)	4.51 ± 1.09 ($p > 0.05$)

This table presents a comparison between males and females for key dermatoglyphic features including fingerprint ridge count, minutiae count, lip print groove count, branches, and convergence zones. The mean values and standard deviations are provided for each feature. The p-values indicate the statistical significance of the observed differences. None of the differences between genders for these features are statistically significant (all $p > 0.05$), suggesting that, within this sample, there are no substantial gender-based variations in these dermatoglyphic characteristics. (Table 2)

Table 3: Correlation between heart rate variability (HRV) and anthropometric parameter of the study group i.e. BMI >30. (N=50)

Age Group	Fingerprint Ridge Count vs Lip Print Groove Count (r)	Fingerprint Minutiae Count vs Lip Print Branches (r)
18-30 years	0.29 ($p < 0.01$)	0.17 ($p < 0.05$)
31-45 years	0.18 ($p < 0.05$)	0.12 ($p > 0.05$)
46-60 years	0.25 ($p < 0.01$)	0.15 ($p < 0.05$)

The results varied by age, indicating that the relationship between these dermatoglyphic characteristics might be influenced by the aging process. Notably, the strongest correlations were observed in the 18-30 years age group for both fingerprint ridge count and lip print groove count, as well as for fingerprint minutiae count and lip print branches. ($p<0.05$). (Table 3)

Discussion

The interplay between dermatoglyphics, specifically fingerprints and lip prints, has been explored in this study for its potential in personal identification, particularly in forensic science and biometrics. The findings reveal intriguing insights into the relationship between these dermatoglyphic features, providing a foundation for further research and practical applications.

The findings of this study regarding the gender-based analysis indicate that there are no statistically significant differences in fingerprint ridge count, minutiae count, lip print groove count, branches, and convergence zones between males and females. This aligns with previous research, which has also highlighted the absence of substantial gender-based variations in these dermatoglyphic features.

Research focused on utilizing fingerprint patterns for gender determination is limited within the existing literature. The investigations conducted by Wijerathne et al. and Mutalik et al. indicated that the loop pattern appeared as the most prevalent in both males and females, followed by whorls and arches. These findings closely align with the outcomes observed in our own study.[6-8]

The most prevalent lip print pattern in females was Type I (45%), while in males it was Type III (34%). Regarding fingerprint patterns, loops were most common in females (66%), and whorls were predominant in males (22%). A potential association was observed between loop fingerprints and Type I lip prints in females, as well as between whorl fingerprints and Type III lip prints in males. However, it's important to note that this correlation was not statistically significant[9,10]. Also, the findings of a study indicated that none of the three parameters, namely lip prints, fingerprints were statistically significant for gender determination.[11]

In this study, the similar patterns of dermatoglyphic features between genders are consistent with prior research, demonstrating the stability of these features across diverse populations.

Additionally, the discussion should acknowledge limitations and potential implications of the findings. While this study provides valuable insights, the sample size and diversity should be expanded in future research to enhance the generalizability of the findings. Practical challenges, such as variations in image quality, should be addressed to refine the identification model for real-world scenarios.

Furthermore, the present study serves as a valuable addition to the broader literature on dermatoglyphics and personal identification. Systematic reviews and meta-analyses play a crucial role in synthesizing existing research evidence, as demonstrated by the increasing importance of such reviews in evidence-based medicine. A systematic review and meta-analysis in the field of dermatoglyphics could provide a comprehensive overview of the existing literature, identifying trends, inconsistencies, and gaps in the research. It could aid in refining the methodology, developing standardized protocols, and establishing a strong evidence base for the interplay between fingerprint and lip print features.

Conclusion

In conclusion, the findings of this study contribute to our understanding of the relationship between fingerprints and lip prints for personal identification. The absence of significant gender-based differences in these features suggests their potential as stable markers for identification purposes. The implications extend beyond gender, highlighting the need for further research to refine the identification model and expand its practical applicability.

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