Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 8s (2025)
https://www.jneonatalsurg.com

Decoding The Twin Code: Exploring Multimodal Biometrics in Identical Twin Differentiation- A Systematic Review

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.Cite this paper as: Sakshi Kumari, Aditi Bhatanagar, Aadhya Agarwal, Ankita Kakkar, Nirupma Gupta, (2025) Decoding The Twin Code: Exploring Multimodal Biometrics in Identical Twin Differentiation- A Systematic Review. *Journal of Neonatal Surgery*, 14 (8s), 980-989.

ABSTRACT

Background: **I**dentical (monozygotic) twins originate from a single fertilized egg that splits early in development, resulting in two individuals with identical DNA. Although they share nearly identical facial features and anatomy, subtle differences can develop over time due to epigenetic and behavioral influences. With the rise in twin births, there is a growing need for biometric systems capable of accurately distinguishing them.Traits such as fingerprints, irises, and palm prints, remain unique due to random developmental factors during gestation. This systematic review examines existing biometric methods and explores the most effective multimodal approaches to enhance accuracy in identifying genetically similar individuals. systematic review is on exploring multimodal biometrics in identical monozygotic twins. differentiation. research question: To identify the most promising multimodal biometric combinations. research question: To analyse advancements in biometric technology that may improve identification reliability in genetically similar individuals.

Methodology: Criteria: Studies that used cross-sectional or survey-based methods were included, while inaccessible reviews and case reports were left out. Strategy: Research was gathered from IEEE Xplore, Embase, SpringerLink, ScienceDirect, PubMed, and Google Scholar **(**2000–2024) using keywords like "Biometrics," "Identical Twins," and "Identification**."** PRISMA guidelines were followed, and reference lists were checked for additional sources. Data Collection: Key details such as study design, participant count, and main findings were recorded. In total, 16 studies involving 1,387 twin pairs were analysed.

Conclusion: Media Reports On Identical Twin Trials Often Highlight The Difficulty Of Identifying The Perpetrator Due To identical DNA. However, biometrics like fingerprints, iris patterns, ear shape, and facial features provide alternative methods (IPRS, 2013). A literature review found fingerprints to be the most reliable, with ear and lip prints showing potential but limited by scarce data.

1. INTRODUCTION

Monozygotic (MZ) twins originate from the division of a single fertilized egg early in development. At the moment of splitting, they share identical DNA. As a result, MZ twins usually exhibit highly similar anatomy and facial features. However, differences in appearance can arise due to behavioral and epigenetic influences. Traditionally, it was believed that MZ twins could not be distinguished through DNA analysis—e.g., "By definition, identical twins cannot be distinguished based on DNA." However, recent advancements have shown that DNA analysis can differentiate MZ twins. A technique known as "ultra-deep next-generation sequencing" has been successfully used to resolve a paternity case involving MZ twins. This method works by identifying random mutations that accumulate over time, allowing for the genetic distinction between MZ twins [1] The birth rate of twins has steadily risen over the past decades, reaching 322 per 1,000 births with an annual growth rate of 3% since 1990 [2] The prevalence of twins has nearly doubled in recent years, driven by the rise in fertility treatments and higher maternal age. Identical twins can exploit their resemblance for fraud, such as one using the other's driver's license. Prosecution is challenging due to their identical DNA, similar appearance, and legal protections in Slovenia concerning human rights and freedoms. This led to the demand for accurate biometric identification systems to distinguish between them. [18]

Lip prints show significant differences among twin pairs. French criminologist Edmond Locard was among the first to propose using lip prints for personal identification and criminal investigations. Lip prints consist of natural lines, fissures, wrinkles, and grooves in the transition zone between the inner labial mucosa and outer skin. Like fingerprints, lip prints are unique and vary from person to person [4].

Fingerprints result from the interaction of genetics and the prenatal environment, forming by the seventh month of fetal development. Their ridge patterns remain stable throughout life, except in cases of injury. Amniotic fluid flow and fetal positioning influence fingerprint formation, creating subtle differences that are amplified during cell differentiation, allowing identical twins to be distinguished 7]. Facial recognition remains desirable for twin identification due to its non-intrusive nature and availability in photos and videos. Sun et al. and Phillips et al. found that still-image methods struggle to distinguish twins, prompting new research directions. Motion-based facial features offer a solution, as humans naturally use facial motion for identification, lifestyle shape expressions, and dynamic differences exist between twins. Studies show that changing expressions improve recognition, and Fraga et al. found twins develop distinct traits due to environment and lifestyle. Even parents rely on motion cues to differentiate their twins[5].

A forensic phonetic study found that identical and non-identical twins can be distinguished using Bayesian likelihood ratios. Handwriting analysis of 206 twin pairs showed that twins can be differentiated, though less distinctly than unrelated individuals. Similarly, a study on palm prints introduced an automatic identification algorithm, revealing a strong correlation in identical twin matching due to shared genetic information [8]. Handwriting uniqueness has been widely recognised with expert analysis methods refined over decades [1–5]. However, quantitative research is needed to evaluate its discriminative power, particularly for its acceptance as evidence in court by questioned document examiners (QDE) [13

Iris biometric systems are also one way to analyse unique textural patterns that remain distinct even among genetically identical individuals. This allows automated iris recognition to effectively differentiate between identical twins. As Wikipedia states, "Even genetically identical individuals have completely independent iris textures." 11] Iris development resembles fingerprint formation, with genetics determining eye colour and epigenetic shaping fine texture details. Daugman and Downing found that iris biometric systems, using Gabor filters and Hamming distance, could not differentiate twin iris from those of unrelated individuals. Similarly, the left and right irises of the same person are uncorrelated. 12] While the ears of MZ twins may be highly similar, studies have noted certain differences. Research has explored inter- and intra-individual earprint variations to evaluate their usefulness for identification. 15]

Face recognition experiments offer a unique approach to distinguishing MZ twins. One such experiment using the Cognitec FaceVACS system found that the "identical twin impostor" distribution was closer to the match distribution than to the general impostor distribution. This suggests that identical twin-face images create more overlap between match and non-match distributions compared to non-twin impostors [17]. As biometric technology advances, fingerprint, iris, and motion-based facial recognition continue to provide promising solutions for distinguishing identical twins, contributing to forensic investigations, security measures, and the broader field of research. This survey reviews biometric methods for identifying identical twins, crucial for medical and scientific purposes

AIM

- A systematic review on multimodal biometrics for identical twin differentiation with the following:
- Identify the most effective multimodal combinations.
- Evaluate biometric advancements improving reliability in genetically similar individuals.

2. MATERIALS AND METHODS

Criteria considered for study selection for this review:

cross-sectional studies and survey-based studies were included, and those studies were accessible. Systematic and meta-analysis, literature review, and case report were excluded, and those which were inaccessible

Search Strategies and Study Selection:

The electronic databases searched for relevant clinical trial reports included PubMed, IEEE Xplore, Springer, Elsevier/Embase Google Scholar. The keywords used for the search of the literature, such as "identical twin biometrics," "twin fingerprint analysis," "iris recognition twins," "face recognition identical twins," and "ear biometrics, " covered almost all studies published from 2005 to 2024. The search strategy has adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines. that had potential eligibility were also identified by reviewing the reference lists of retrieved articles. After removing duplicate entries, two independent reviewers screened titles and abstracts for potential eligibility manually. All the full-text articles after a thorough review that passed the screening phase were then assessed by the reviewers to confirm whether they met the inclusion criteria or not. A third reviewer then resolved conflicts between the reviewers.

Findings:

Overall, the findings show that iris recognition is the most effective biometric method for distinguishing identical twins, followed by fingerprint analysis when high-resolution scanners and AI-based minutiae are used. Face recognition, on the other hand, performed poorly for identical twins due to their near-identical facial structures but could be enhanced by deep learning and facial motion analysis. Ear biometrics have shown promise, with studies since ear shape remains stable over time and can be a distinguishing factor between twins. However, further validation is required. In contrast, handwriting analysis was found to be unreliable, as studies showed that twins often have highly similar handwriting, making differentiation challenging for AI-based handwriting analysing systems.

Data Extraction:

Data was collected independently by two viewers using a pre-designed data collection form. This process involved gathering detailed pieces of information from the included studies, including author, study design, publication year, country of origin, study population, interventions, and their results.

Synthesis and Interpretation

This systematic review explores the certainty of different biometric models in distinguishing identical twins, a challenge due to their shared genetic code and similar physical characteristics.

The findings suggest that no single biometric method is entirely up to mark, but some techniques offer better results than others. Iris recognition emerges as the most dependable method, as iris patterns develop randomly in the womb and remain unique even among identical twins. This makes iris scans the preferred choice for high-security authentication systems. Followed by fingerprint evaluation, as twins have highly similar but not identical fingerprints. High-resolution imaging and AI-powered analysis can detect subtle ridge differences, making fingerprint biometrics almost accurate but not completely differentiating. Whereas, facial recognition struggles with identical twins since most of the facial structures are nearly identical in twins. However, advancements in facial motion tracking and expression analysis may improve dependency in the future. An unexpected finding is that ear biometrics could be a promising alternative. Unlike facial features, ear structures remain stable over time, and even identical twins have slight variations, providing an alternative method. However, ear biometrics is still an underexplored area with limited real-world application. In contrast, handwriting analysis is one of the least effective biometric markers, as twins often develop nearly the same writing styles due to shared learning environments.

Assessment of Heterogeneity

Heterogeneity refers to the variation in study results that can be due to differences in study design, populations, interventions, and outcomes. Determining this is important in determining how broad the systematic review findings are and whether it is possible or not to conduct a meta-analysis. A number of the studies included in the review may have used different study frameworks, for example, retrospective and prospective cohort studies, prospective trials, and RCTs. This may also provide explanations for differences in outcomes whereby observational studies are likely to be biased while RCT's more stringent controls are applied. The inclusion and exclusion criteria in each study may vary (for example, the age of the mother and the fertilization process), and hence different populations are studied.

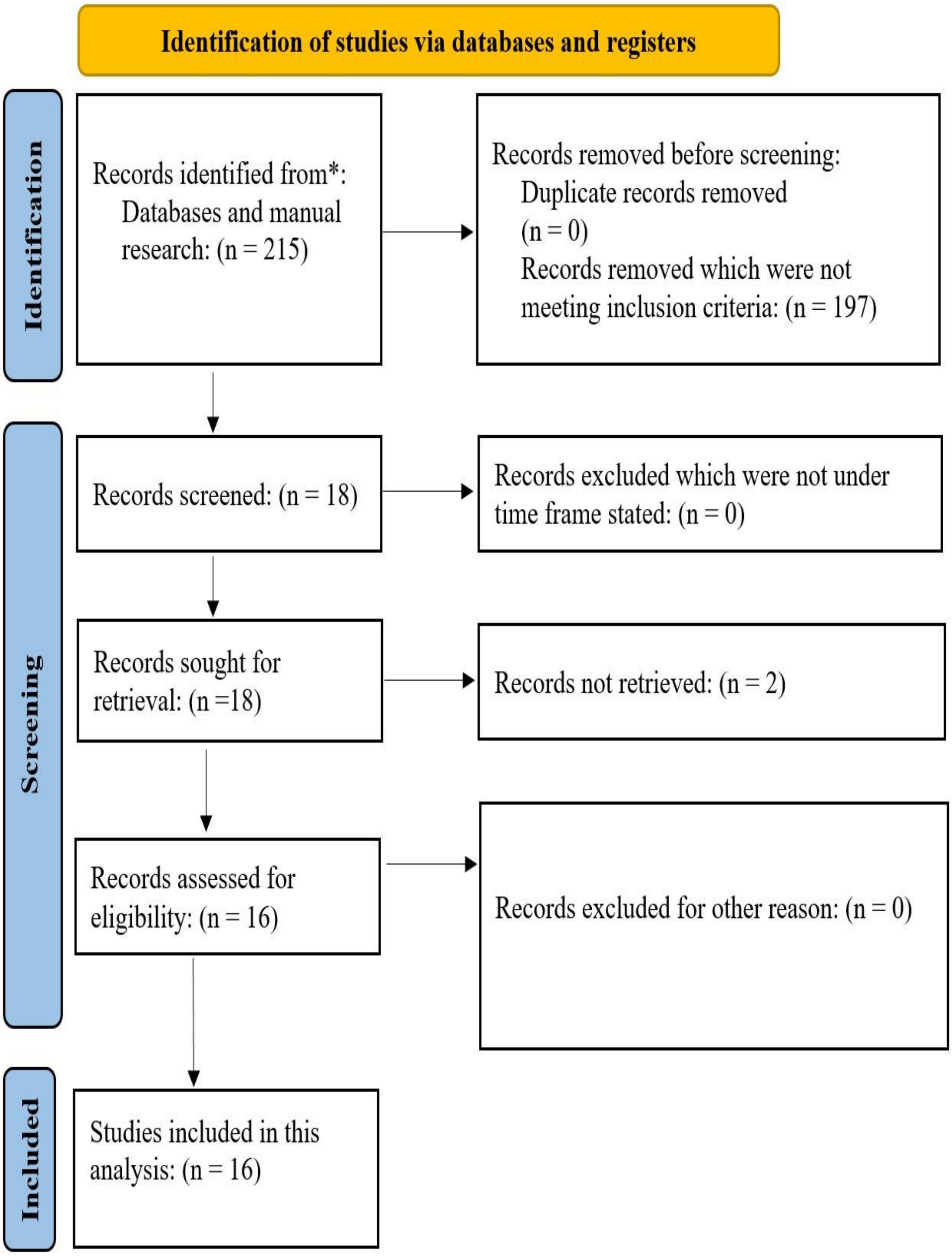
Differences in the age range, sex, environmental exposure, epigenetic factors and developmental variations can be a factor to introduce variability in how different biometric analyzing systems impact outcomes to distinguish between twins. Biometric Traits that were assessed,s ome studies focused on fingerprints, while others on iris recognition, facial features, or ear structure, this use of different methods leads to inconsistencies in results. The accuracy of these biometrics varied depending on imaging resolution, data processing techniques, and algorithm complexity used in different studies.

The heterogeneity seen in sample size like the number of twin pairs included varied significantly across studies, ranging from a few dozen pairs to over a thousand twin pairs. Some studies analysed monozygotic (identical) twins, while others included dizygotic (fraternal) twins for comparison, adding to the variability in findings. Algorithms & Analytical Techniques also add to the heterogeneity factor as they use different AI and machine-learning models, leading to variations in matching accuracy and presence of deep-learning models vs. traditional biometric analysis. Differences in evaluation metrics made cross-study comparisons also challenging.

3. RESULT

A total of 16 studies, with 1387 pairs of twins were included.

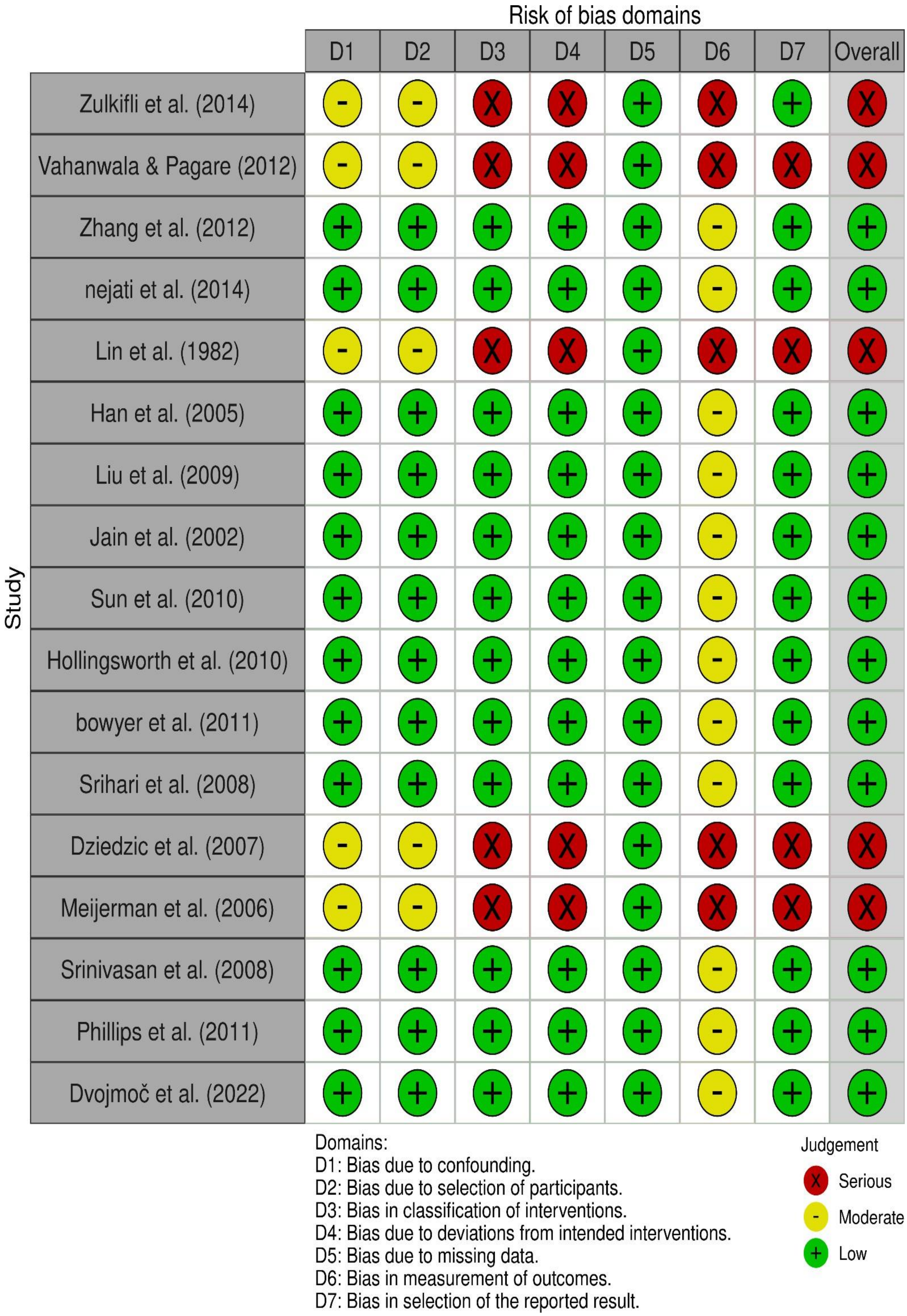
PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

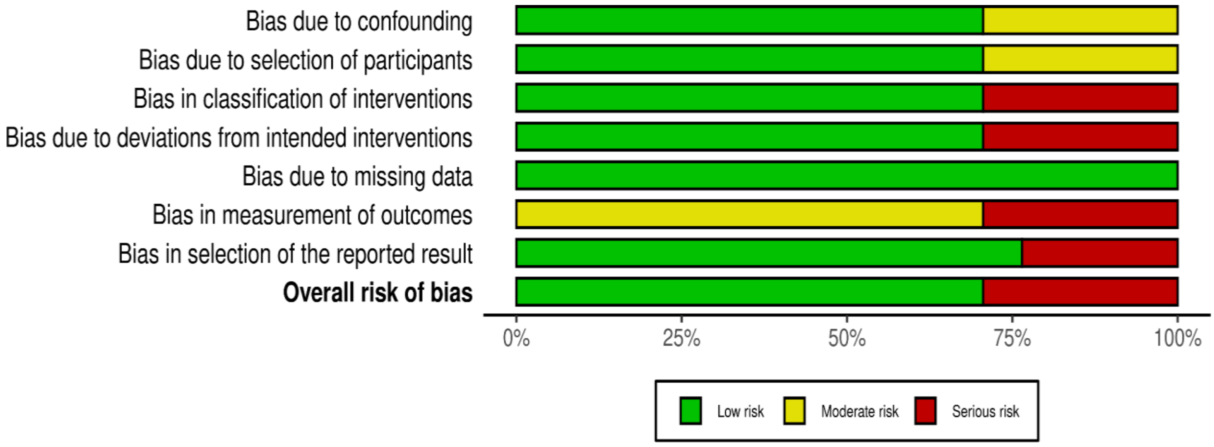


*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

STUDY	STUDY POPULATION	METHODS	RESULT
1. Zulkifli et al. (2014) (Malaysia) [3]	95 pairs of Identical twins	Ear anthropometric measurements compared.	Most twin pairs exhibited similar external ear features, including ear type, shape, and lobule. Ear base length of left ear is only significantly different in external ear landmarks between monozygotic twins.
2. Meijerman et al. (2006) (Netherlands) [15]	6 pairs of Identical Twins.	Right ear prints of twins were collected (3 times each), dusted with aluminium powder, lifted with black gel lifters, scanned at 600 dpi, and inverted to black-on-white.	6 pairs of MZ ear prints were analyzed. After comparing prints visually and with digital overlays, they found that an expert could identify diagnostic differences between prints from twin members, which could exclude one twin as the donor. For most pairs, differences in imprinted feature positions were within expected limits. Cluster analysis showed that features were more similar within the same ear than between different ears (twin members).
3. Vahanwala et al. (2012) (Maharashtra) [4]	25 pairs of Identical Twins.	Two labelled sets of lip prints were collected for each twin pair.	Difference in lip-patterns were found in 24 pairs whereas, 1 pair had identical pattern and interestingly 3 pairs have mirror image of upper lip and lower lip in 2 pairs, same pattern was found in only 1 pair. This can be a reliable method for forensic identification.
4. Zhang et al. (2012, 14) (Singapore, Spain) [5]	39 pairs of Identical Twins.	Facial motion analysis of twins speaking, focusing on six types of facial motion in a talking profile.	Experimental research demonstrated that facial motion outperforms facial appearance in distinguishing twins. They propose a two-stage cascaded General Access Control System that integrates both facial appearance and motion (Mainly in Evil-twin subjects).
5. Phillips et al. (2011) (USA) [17]	150 pairs of Identical Twins.	A match face pair includes two images of a person with their identical twin. Performance metrics, such as false reject rate (FRR) and	Results show that there is promise for distinguishing identical twins under ideal conditions (same day, studio lighting and neutral expression).
		verification rate (VR), are calculated from these pairs.	
6. Nejati et al. (2012) (Singapore, Australia) [2]	39 pairs of Identical Twins.	Automatic twin identification from ear images uses the Exception Report Model (ERM), a psychological model for face recognition.	Their results suggest that ears are a powerful identification feature, not only for regular individuals but also for identical twins, where other methods like face recognition often fail [17]. Exception Report Model (ERM) is used which give comparable differences between the levels of resolution, Occlusion, Noise, Right & Left ear.
7. Lin et al. (1982) (USA) [6]	38 pairs of Identical Twins.	Finger prints biometric compared.	It is concluded that fingerprint similarities—such as pattern, ridge count, and potentially minutiae—are significantly greater between monozygotic (MZ) twins than between other population groups, including dizygotic (DZ) twins.
8. Han et al. (2005) (South Korea) [7]	51 pairs of Identical Twins.	Live-scanned fingerprints from twins were analyzed for uniqueness using fingerprint type similarity and minutia-based matching scores in an evaluation framework.	The results show that fingerprints are distinct enough to differentiate individuals, with only a minimal decrease in recognition accuracy for identical twins.

STUDY	STUDY POPULATION	METHODS	RESULT
9. Liu et al. (2009) (USA) [8]	188 pairs of Identical Twins.	The dataset for this study included friction ridge patterns of twins, with ten fingerprints per individual.	Identical twins have a 62.78% likelihood of sharing the same fingerprint ridge flow versus 26.5% for non-twins in Level-1 results. In Level-2 results showed Minutiae-based matching shows a 1.5%–1.7% higher Equal Error Rate (EER) for twins, making them harder to distinguish than unrelated individuals, yet distinct from genuine prints of the same finger.
10. Jain et al. (2002). (USA) [9]	94 pairs of Identical twins	Rolled fingerprint impressions were initially recorded on paper and scanned at 500 dpi.	Their high-level results align with those of Lin et al. [6]. Analyzing five ridge patterns—right loop, left loop, whorl, arch, and tented arch—they found a 0.2718 probability that two random index fingers share the same pattern, compared to a 0.775 probability for identical twins [9].
11. Srihari et al. (2008) (USA) [16]	298 pairs of Identical Twins.	Live-scan rolled fingerprints from twins were captured; Level 1 analysis classified six fingerprint types, and Level 2 compared minutiae on ridge endings and bifurcations.	Twins are more likely (55%) to share the same level 1 fingerprint classification compared to the general population (32%). Level 2 analysis showed that twins differ from non-twins and genuine fingerprints, but identical and fraternal twins are indistinguishable.
12. Sun et al. (2010) (China) [10]	51 pairs of Identical Twins.	Iris images (10 per subject) were captured using the IKEMB-100 camera by IrisKing, with a 480×640 resolution and an iris diameter of approximately 200 pixels.	Iris matching can distinguish identical twins as effectively as unrelated individuals, with iris recognition outperforming other single-biometric methods. This may be due to lower correlation between twins' irises and higher image quality. 2-iris fusion further improved performance.
13. Hollingsworth et al. (2010) (Australia) [11,12]	76 pairs of Identical Twins.	Iris video data was collected using an LG 2200 EOU camera. The analog signal was captured, digitized, and stored in a high bit-rate, effectively lossless MP4 format.	Untrained humans can classify twin pairs with over 81% accuracy using only the iris appearance, excluding features like eyelashes, eyelids, or tear ducts. When confident, their accuracy exceeds 92%.
14. Dziedic et al. (2007) (Poland) [14]	31 pairs of Identical Twins.	The analysis focused on writing and signature samples.	The examination showed more differences than similarities in handwriting among both MZ and DZ twins. While MZ twins had slightly more similarities, the difference was minimal (6%-11%).
15. Srihari et al. (2008) (USA) [13]	206pairs of Identical Twins.	Automated handwriting analysis for twin identity verification was done tuned the CEDAR-FOX system	Handwriting verification shows higher error rates for twins (12.91%) than non-twins (3.7%), with more errors for identical than fraternal twins. Error rates decrease by rejecting borderline cases. The system performs comparably to humans, with lower errors than laypersons but higher than questioned document examiners (QDEs).


Risk of bias domains
D1
D2
D3
D4
D5
D6
D7
Overall
Study
Zulkifli et al. (2014)
Vahanwala & Pagare (2012)
Zhang et al. (2012)
nejati et al. (2014)
Lin et al. (1982)
Han et al. (2005)
Liu et al. (2009)
Jain et al. (2002)
Sun et al. (2010)
Hollingsworth et al. (2010)
bowyer et al. (2011)
Srihari et al. (2008)
Dziedzic et al. (2007)
Meijerman et al. (2006)
Srinivasan et al. (2008)
Phillips et al. (2011)
Dvojmoč et al. (2022)
Domains:
D1: Bias due to confounding.
D2: Bias due to selection of participants.
D3: Bias in classification of interventions.
D4: Bias due to deviations from intended interventions.
D5: Bias due to missing data.
D6: Bias in measurement of outcomes.
D7: Bias in selection of the reported result.
Judgement
Serious
Moderate
Low



4. DISCUSSION

The findings of this systematic review provide a comprehensive analysis of the effectiveness of multimodal biometric systems in differentiating identical twins. As identical twins share nearly identical DNA and highly similar physical features, traditional biometric methods often face significant challenges in distinguishing them. However, this review highlights that certain biometric traits—such as iris recognition, fingerprints, and ear biometrics—hold significant promise in addressing this challenge.

Effectiveness of Multimodal Biometrics

Among the various biometric techniques analyzed, iris recognition emerged as the most reliable method for twin differentiation. The unique textural patterns of the iris develop independently in each individual, even among genetically identical twins, making iris biometrics highly accurate[11]. This supports previous research emphasizing the stability and uniqueness of iris structures over time (Daugman & Downing, 2001).

Fingerprint analysis was also found to be an effective modality, though not as foolproof as iris recognition. While identical twins share highly similar fingerprint ridge patterns, minor variations exist due to prenatal environmental influences. Studies utilizing high-resolution scanners and AI-based minutiae analysis demonstrated improved accuracy in distinguishing twin fingerprints, highlighting the role of technological advancements in enhancing biometric reliability [8].

Ear biometrics showed promise as an emerging modality, given that ear shapes remain stable throughout life and exhibit subtle differences even among identical twins [2]. However, this area of research remains underexplored, and further validation studies are needed to confirm its forensic applicability [15].

On the other hand, facial recognition performed poorly in differentiating identical twins due to their near-identical facial structures. Despite this, recent advances in facial motion analysis and deep learning techniques offer potential improvements. The inclusion of dynamic facial features, such as expressions and micro-movements, has been suggested as a way to enhance differentiation accuracy in future biometric systems[17]

Limitations of Certain Biometric Methods

While some biometric traits proved to be effective, others exhibited limitations. Handwriting analysis was found to be unreliable, as identical twins often develop highly similar handwriting styles due to shared environmental and educational experiences [13]. Similarly, lip prints, though unique, lack sufficient research and standardization, making them less viable for forensic applications [4].

Additionally, forensic phonetics and voice recognition techniques were examined, but the results indicated considerable overlap in speech patterns between twins, reducing their effectiveness as a stand-alone biometric tool. This suggests that certain biometric modalities may require augmentation with other methods to enhance differentiation accuracy[14].

Challenges and Future Directions

The heterogeneity observed in the included studies underscores several challenges in the field of twin biometrics. Variations in sample size, study design, imaging technology, and analytical techniques contributed to inconsistencies in reported accuracy rates across different biometric modalities. Additionally, some studies included dizygotic (fraternal) twins for comparison, which may have influenced overall findings [1].

Despite these challenges, the results emphasize the need for multimodal biometric systems, integrating multiple biometric traits to maximize differentiation accuracy. Future research should focus on developing AI-powered, deep-learning algorithms capable of analyzing a combination of biometric markers in real time. Further validation studies using larger twin datasets and standardized evaluation metrics will be crucial in refining forensic and security applications [10].

Implications for Forensic and Security Applications

The inability to reliably distinguish identical twins has posed significant challenges in forensic investigations and legal proceedings. Traditional DNA analysis alone is insufficient in cases involving twin suspects, making biometric methods critical for ensuring justice. The findings from this review suggest that high-resolution iris and fingerprint recognition systems should be prioritized in forensic and security settings. Additionally, advancements in facial motion tracking and ear biometrics could further enhance identification reliability 18.

In forensic investigations, integrating multimodal biometric authentication systems—such as combining iris, fingerprint, and facial motion analysis—could significantly improve the accuracy of twin differentiation. Law enforcement agencies, border security, and forensic experts should consider implementing such systems to address cases where DNA evidence alone is inconclusive [17].

5. CONCLUSION

This systematic review highlights the importance of advanced biometric technologies in distinguishing identical twins. While no single biometric method offers complete accuracy, iris recognition, fingerprint analysis, and ear biometrics demonstrate the highest potential for reliable differentiation. However, continued research and technological advancements are necessary to refine multimodal biometric frameworks. Future studies should focus on enhancing AI-driven biometric authentication systems and validating new methods with larger, more diverse twin datasets. By strengthening biometric identification methodologies, forensic science and security sectors can overcome the longstanding challenge of identical twin differentiation, ensuring justice and accuracy in criminal investigations.

6. CONCLUSION

Limited research, particularly in India, lacks comprehensive and accurate data on forensic identification methods, including facial recognition, handwriting analysis, ear prints, and iris texture. These gaps highlight the need for more rigorous studies to refine forensic techniques. Future research should prioritize enhancing identification accuracy, especially in cases where DNA evidence is unavailable or insufficient. This is crucial for ensuring justice in complex legal scenarios, such as when identical twins deny involvement in a crime. Strengthening biometric and forensic methodologies will improve the reliability of evidence, aiding law enforcement and the judiciary in making fair and accurate decisions

REFERENCES

[1] Bowyer KW, Flynn PJ. Biometric identification of identical twins: A survey. In2016 IEEE 8th international conference on biometrics theory, applications and systems (BTAS) 2016 Sep 6 (pp. 1-8). IEEE.

[2] Nejati H, Zhang L, Sim T, Martinez-Marroquin E, Dong G. Wonder ears: Identification of identical twins from ear images.InProceedings of the 21st International Conference on Pattern Recognition (ICPR 2012) 2012 Nov 11 (pp. 1201-1204). IEEE.

[3] Zulkifli N, Yusof FZ, Rashid RA. Anthropometric comparison of cross-sectional external ear between monozygotic twins. Ann Forensic Res Anal. 2014;1(2):1010.

[4] Vahanwala S, Pagare SS. Evaluation of lip-prints in identical twins. Medico-Legal Update. 2012;12(2):192-6.

[5] L. Zhang, N. Ye, W. Martinez Marroquin, D. Guo, T. Sim, New hope for recognizing twins by using facial motion, IEEE Workshop on Applications of Computer Vision (WACV), 209-214, 2012. [65] & L. Zhang, K. Ma, H. Nejati, L. Foo, T. Sim and D. Guo, A talking profile to distinguish identical twins, Image and Vision Computing 32(10):771–778, 2014

[6] C. H. Lin, J. H. Liu, J. W. Osterburg and J. D. Nicol, Fingerprint Comparison. I. Similarity of Fingerprints, J. of Forensic Sciences 27 (2), 290-304, 1982.

[7] Y. Han, C. Ryu, J. Moon, H. Kim, H. Choi, A Study on Evaluating the Uniqueness of Fingerprints Using Statistical Analysis, in Information Security and Cryptology, LNCS Volume #3506, 467-477, 2005.

[8] Y. Liu, S. N. Srihari, A Computational Discriminability Analysis on Twin Fingerprints, in Computational Forensics: Third Int. Workshop on Computational Forensics (IWCF 2009), Springer, 43-54, 2009.

[9] A. K. Jain, S. Prabhakar, S. Pankanti, On the similarity of identical twin fingerprints, Pattern Recognition 35:2653 – 2663, 2002.

[10] Z. Sun, A. Paulino, J. Feng, Z. Chai, T. Tan, and A. K. Jain. A study of multibiometric traits of identical twins.

Proc. SPIE 7667: Biometric Technology for Human Identification VII, 76670T, 2010. \

[11] K. Hollingsworth, K. Bowyer, and P. Flynn, Similarity of iris texture between identical twins, IEEE Conf. on Computer Vision and Pattern Recognition Workshops, pp. 22–29, 2010.]

[12] K. Hollingsworth, K.W. Bowyer, S. Lagree, S.P. Fenker and P.J. Flynn. Genetically Identical Irises Have Texture Similarity That Is Not Detected By Iris Biometrics, Computer Vision and Image Understanding 115, Pages 1493–1502, 2011.

[13] S. Srihari, C. Huang and H. Srinivasan, On the Discriminability of the Handwriting of Twins, J. Forensic Science 53(2):430-446, 2008.

[14] T. Dziedzic, E. Fabianska, Z. Toeplitz, Handwriting of Monozygotic and Dizygotic Twins, Problems of Forensic Sciences LXIX, 30–36, 2007.

[15] Meijerman L, Thean A, van der Lugt C, van Munster R, van Antwerpen G, Maat G. Individualization of earprints: Variation in prints of monozygotic twins. Forensic Science, Medicine, and Pathology. 2006 Mar;2:39-49.

[16] S. N., Srihari, H. Srinivasan and G. Fang, Discriminability of fingerprints of twins, J. of Forensic Identification 58(1):109-127, 2008.

[17] P. J. Phillips, P. J. Flynn, K. W. Bowyer, R. W. Vorder Bruegge, P. J. Grother, G. W. Quinn, M. Pruitt, Distinguishing Identical Twins by Face Recognition, IEEE Int. Conf. on Automatic Face & Gesture Recognition and Workshops (FG), 185 – 192, 2011.

[18] Dvojmoč M, Klavžar VM, Erčulj V. Identification of identical twins in police procedures. Varstvoslovje. 2022 Oct 1;24(4):281-97