Comparison Of Gait Pattern in Identical Twins Through 2d Measurement: A Forensic Perspective

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***Abstract*—Gait analysis has emerged as a valuable biometric tool in forensic science, particularly in cases where traditional identification methods such as DNA profiling fail to distinguish between individuals. This study examines the effectiveness of gait pattern analysis in differentiating identical (monozygotic) twins using two-dimensional (2D) footprint measurements. Identical twins share nearly identical genetic material, making conventional forensic identification methods inadequate in certain scenarios. Therefore, this research explores whether measurable gait parameters—such as step length, stride length, step width, and foot angle—can provide reliable distinguishing features. The study involved collecting 2D footprint samples from identical twins under controlled conditions using ink-based walking techniques. The collected data were analysed using statistical tools, including paired t-tests, to determine the presence of significant differences between twin pairs. The findings revealed minor variations in gait parameters; however, these differences were not statistically significant ($p > 0.05$), indicating a high level of similarity in walking patterns among identical twins. The study concludes that while gait analysis demonstrates potential as a supportive forensic tool, it cannot serve as a standalone method for differentiating identical twins. Further advancements in analytical techniques and integration with other biometric methods are essential to enhance forensic identification accuracy.**

***Index Terms*—Gait Analysis, Identical Twins, Forensic Science, Footprint Measurement.**

I. INTRODUCTION TO GAIT ANALYSIS IN FORENSIC SCIENCE

Gait refers to the manner or pattern of walking exhibited by an individual. It is a complex biomechanical process influenced by anatomical, neurological, and environmental factors. In forensic science, gait analysis is increasingly used as a biometric tool to identify individuals based on their walking style. Each person's gait is considered unique due to variations in body structure, muscle coordination, and movement patterns.

The significance of gait analysis becomes particularly evident in criminal investigations where traditional identification methods are limited. Surveillance footage, footprints, and walking patterns can provide crucial evidence linking suspects to crime scenes. Unlike fingerprints or DNA, gait can be observed from a distance without direct contact, making it a non-invasive and practical identification method.

This study focuses on the forensic challenge of distinguishing identical twins, who share nearly identical genetic profiles. Since DNA evidence cannot differentiate between them, alternative biometric methods such as gait analysis become essential. The research aims to evaluate whether measurable gait parameters can provide reliable distinguishing characteristics between identical twins.

II. CONCEPT, PHASES, AND PARAMETERS OF GAIT PATTERN

The gait cycle consists of two primary phases: the stance phase and the swing phase. The stance phase occurs when the foot is in contact with the ground, accounting for approximately 60% of the gait cycle, while the swing phase represents the remaining 40%, during which the foot is off the ground.

Several measurable parameters define gait patterns. These include stride length, step length, step width, and foot angle. Stride length refers to the distance covered between two consecutive heel strikes of the same foot, while step length measures the distance between successive foot placements. Step width indicates the lateral distance between the feet, and foot

angle represents the orientation of the foot during movement.

These parameters are influenced by factors such as age, height, gender, and physical condition. Variations in these parameters can provide valuable insights into an individual's walking pattern. In forensic investigations, accurate measurement of these variables is essential for identifying similarities or differences between individuals.

III. IDENTICAL TWINS AND CHALLENGES IN FORENSIC IDENTIFICATION

Identical twins originate from a single fertilized egg that splits into two embryos, resulting in individuals with nearly identical genetic makeup. This genetic similarity presents significant challenges in forensic science, particularly in cases where DNA evidence is the primary method of identification.

Traditional biometric methods such as fingerprints and footprints offer some degree of differentiation due to environmental and developmental factors. However, these differences are often subtle and may not be sufficient for conclusive identification. Gait analysis has been proposed as an alternative approach, as it reflects dynamic movement patterns influenced by both genetic and environmental factors.

Despite their genetic similarity, identical twins may exhibit slight differences in gait due to variations in lifestyle, physical condition, and environmental influences. This study explores whether these differences are significant enough to serve as reliable forensic indicators.

IV. REVIEW OF LITERATURE ON GAIT ANALYSIS AND TWINS

Previous studies have explored the application of gait analysis in forensic identification. Research indicates that gait recognition can achieve high accuracy in distinguishing unrelated individuals. However, its effectiveness in differentiating identical twins remains limited.

Studies involving wearable sensors, motion capture systems, and video-based analysis have demonstrated the potential of gait as a biometric tool. However, these methods often require advanced technology and controlled environments, limiting their practical application in real-world forensic scenarios.

Literature also highlights the influence of external factors such as footwear, terrain, and psychological state on gait patterns. These factors introduce variability, making it difficult to establish consistent distinguishing features. The current study builds upon existing research by focusing on 2D footprint analysis as a practical and accessible method for gait measurement.

V. METHODOLOGY: COLLECTION AND ANALYSIS OF 2D GAIT SAMPLES

The methodology involves collecting 2D footprint samples using a controlled experimental setup. Participants walked barefoot on a white sheet coated with ink to capture clear footprints. Measurements were taken using metric tools to ensure accuracy and consistency.

Key gait parameters were recorded for each participant, including step length, stride length, step width, and foot angle. Multiple samples were collected to minimize errors and ensure reliability. The collected data were analysed using statistical methods, particularly paired t-tests, to compare the gait patterns of identical twins.

This approach provides a cost-effective and practical method for gait analysis, making it suitable for forensic applications where advanced technology may not be available.

VI. RESULTS AND STATISTICAL INTERPRETATION

The analysis revealed minor variations in gait parameters between identical twins. Differences were observed in step length, stride length, step width, and foot angle; however, these variations were not statistically significant.

The paired t-test results indicated that the observed differences fell within the range of natural variability, suggesting a high degree of similarity in gait patterns. This finding highlights the limitations of using gait analysis as a sole method for differentiating identical twins.

Despite the lack of significant differences, the study provides valuable insights into the consistency of gait patterns among genetically identical individuals.

VII. DISCUSSION: FORENSIC IMPLICATIONS OF GAIT ANALYSIS

The findings of this study have important implications for forensic science. While gait analysis offers a non-invasive and practical method for identification, its limitations must be acknowledged. The high similarity in gait patterns among identical twins reduces its reliability as a standalone identification tool.

However, gait analysis can still serve as supportive evidence when combined with other forensic methods. For example, integrating gait analysis with footprint examination, video surveillance, and behavioural analysis can enhance the accuracy of identification.

The study also highlights the need for advanced analytical techniques, such as machine learning and 3D motion analysis, to improve the sensitivity and reliability of gait-based identification.

VIII. LIMITATIONS AND FUTURE SCOPE

Several limitations were identified in this study. The sample size was limited, which may affect the generalizability of the findings. Additionally, the use of 2D analysis restricts the ability to capture dynamic movement patterns.

Future research should focus on incorporating advanced technologies such as 3D motion capture and wearable sensors to enhance the accuracy of gait analysis. Expanding the sample size and including diverse populations can also improve the reliability of results.

The integration of artificial intelligence and machine learning techniques offers promising opportunities for improving gait recognition systems in forensic applications.

IX. CONCLUSION

This study provides a comprehensive analysis of gait patterns in identical twins using 2D footprint measurements. The findings demonstrate that while minor variations exist, these differences are not statistically significant, indicating a high degree of similarity in gait patterns among identical twins.

The study highlights the limitations of gait analysis as a standalone forensic tool, particularly in cases involving genetically identical individuals. However, it also emphasizes its potential as a supportive method when combined with other forms of evidence.

Advancements in technology and analytical techniques are essential to enhance the accuracy and reliability of gait analysis. Future research should focus on integrating multiple biometric methods to overcome the challenges associated with identical twin identification.

In conclusion, gait analysis remains a valuable tool in forensic science, but its application must be carefully considered within the broader context of forensic evidence.

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