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Forensic Gait Analysis: The Correlation between Gait Characteristics and Stature of Male and Female for Criminal Profiling

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Abstract

Forensic gait pattern analysis is the scientific and systematic evaluation of different gait characteristics involved in gait pattern left at scene of occurrence during crime by criminal, victim, or any other person and it is used as a parameter because of their individualistic nature to eliminate suspect list as it contribute in personal identification of any suspect related to the crime scene, meanwhile helps investigating officer to make a criminal profile. Gait pattern is the way of walking or a manner of movement of lower limbs during locomotion of any person and it constitutes some feature during development of walking pattern like step length, step width, step angle, foot angle, etc. Which is somehow individualistic? And gait pattern is countered as a evidence in number of crime scene robbery, hit and run, homicides, kidnapping, etc. The present study expecting probable correlation between four gait characteristics which is step length, step width, step angle and foot angle of person and stature in both male and female separately. And will be developed as a forensic tool which provide us relevant information like stature, gender of the person and help to generate criminal profile.

Keywords: Correlation • Forensic science • Criminal profile • Gait pattern • Lower limb

Introduction

Gait analysis is known as the systematic study of human locomotion. Forensic gait analysis or forensic gait comparison is defined as 'the assessment and evaluation of the gait patterns and features of the person/suspect and comparing these features with the scene of crime evidence for criminal/personal identification [1]. In other words, forensic gait analysis may be defined as a contributor to the identification process rather than one of the methods of identification as individualization of the gait of a person has not yet been fully scientifically proved. The forensic gait analysis general source or evidence comprises the series of footprints found at the crime scene and the Closed-Circuit Television Camera (CCTV) footage. Footprints are one of the pieces of evidence encountered at the crime scene [2]. Footprints can be recovered in the form of bare prints, shoeprints as well as a series of imprints. Footprints can be encountered in several types of cases and crime scenes such as HBT (House Break-in and Theft), robbery, hit and run, shoplifting, homicides, kidnapping, etc. The science of footprints and gait analysis is a part of an emerging sub-discipline of forensic science known as forensic podiatry. Forensic podiatry is "the application of podiatric knowledge and experience in forensic investigations. It shows the association of an individual with a scene of a crime, or to answer any other legal question concerned with the foot or footwear that requires knowledge of the functioning foot. Meanwhile, an investigating officer is always on the look-out for evidence that will link the suspect to the scene of the crime [3]. In recent times, gait analysis has emerged as an important parameter that can help in personal identification during forensic examinations. The advent of CCTV cameras and other surveillance means has generated interest in the practice and research related to forensic gait analysis and its possible use in human individualization.

Literature Review

Gait analysis

Human walking occurs in a specific pattern, including various stages, which are referred to as a gait cycle. It mainly consists of two phases, i.e., the stance phase and the swing phase. The stance Phase constitutes five stages: "Initial contact, loading response, mid-stance, terminal stance, pre-swing." While the swing phase

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constitutes three stages, namely; "initial swing, mid- swing, terminal swing. The forensic gait analysis would depend on the type of gait pattern. The gait pattern may be classified into the following two types.

Gait analysis on the surface

The analysis of gait pattern on the surface (consisting of a minimum of 3 to 4 consecutive footprints/footwear prints) is performed by considering various parameters including the dimensions, general shape of the prints, patterns in case if ridges are visible, margins of the prints, toe marks, etc. The measurements pertaining to step and stride length are taken into consideration, which may point out the nature of an individual's gait pattern, such as normal gait, running, etc., and associated abnormalities, if any. This analysis may also help approximate stature, gender, age, and the bodyweight of a suspect. A profile of the contributor of the prints may be established. A comparison between the perpetrators of the crime with that of the suspect is made by systematically analyzing and scoring the gait patterns. The information related to the relationship of step length, stride length and footprint length with stature may provide valuable information in the gait comparison process and analysis. Some researchers have found a statistical correlation between footstep length and stride length with the stature of a person taking into consideration various controlled conditions.

Gait analysis from CCTV footage/video recording

The emergence of CCTV cameras and video recording enabled devices (video cameras, mobile phones, dashboard cameras, surveillance cameras, traffic cameras, etc.) has given a fresh dimension to gait analysis. Currently, video recording and footages from CCTV are used to study the gait of the person.

Forensic gait analysis features/parameters

For any traits or features to be useful for forensic purposes, it has to follow certain principles like universality, permanence, and uniqueness. While some may be grouped under class characteristics and some under individual characteristics. Even if one or two features may not be proof enough for a conclusion, it will result in a more reliable and scientifically sound result when these features are combined. Although it is beyond the purview of this article to detail the parameters/features used and factors affecting the forensic gait analysis, a brief account is given.

Spatial parameter (distance)

These parameters can be measured using the measurement of footprints by drawing a progression line, which is an imaginary line corresponding to the direction of walking. The parameters that may be included are step length, stride length, stride length/leg length ratio, stride or step width, longitudinal dimension, horizontal dimension, dimensions of the foot, foot line, direction line, foot angle, gait line, etc.

Temporal parameter (time)

In the videos/footage, these parameters are measured using a stopwatch (manually) or with the help of automated/semi- automated software. It includes step time, stride time, stance duration, swing duration, swing/stance ratio, speed, cadence, etc.

Angular displacement parameter (angle)

Various angles like hip angle, knee angle, are also considered.

The author with the assistance of the co-author Shanu Kumar Jharkhand Raksha Shakti University had conducted a research on proposed research. The correlation between gait characteristics and stature of male and female for criminal profiling" was carried out to study the correlation between height of the person and different gait characteristics. There are various methodology involved in the past research to record gait pattern of the person in this research study there are multiple steps are followed.

Dusted 2D barefoot walking impressions gait print was collected from 80 random subjects. The 2D gait patterns have been collected from the random subjects by the method. The subject is directed to remove her footwear and asked for his/her gender, height, age, and recorded in table chart then we took their consent to record their gait pattern in a long white sheet of paper spreaded on the floor for academic research purpose and requested to walk in normal manner as they walk in daily life routine and cross over the paper. After that the imprint of consecutive four to six footprint is marked by paper and the parameters as mentioned.

The various parameters used in gait pattern analysis include:

- **Direction line:** It is an imaginary line along the centre of the path followed by the subject.
- **Gait line:** It is the line actually followed. It is obtained by joining the centers of the heel line.
- **Foot line:** It is the line of, the foot or footwear.
- **Foot angle:** It is the angle between the foot line and the direction line.
- **Gait angle:** It is the angle between the consecutive footlines. It is equal to the sum of the two foot angles.
- **Step length:** It is the distance between the centers of two consecutive heel marks.
- **Step width:** The distance between the tangents to the extreme edges of the two feet or two footwear marks gives step width. The evaluation of gait pattern is possible from four consecutive foot or footwear marks even though six footsteps were recorded. After collecting the gait samples from the subjects having different height, proper and detailed measurements have been made on the gait patterns and the measured parameters are tabulated. Thorough and keen analysis of gait pattern indicated that no two persons have the same gait pattern and thus individual identification may be possible by gait pattern analysis (Figures 1 and 2).

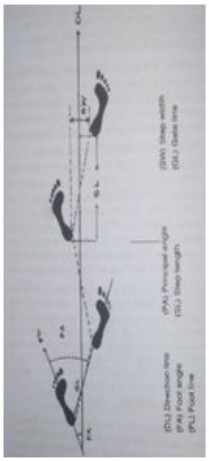

Figure1: Parameters in the gait pattern.

Figure2: Recorded in the gait pattern.

Discussion

The conducted research thus tells us that the step length, step width, step angle, And foot angle doesn't depends upon the gender of the person this result is obtained by performing t-test. It is found that the average step length in male having height ranges from 5 ft to 5 ft 5inches is approximately 51 cm or 20 inches in females and 55 cm or 22 inches in males [4]. Wherever in height ranges from 5 ft 5inches to 6ft the average step length of male is 70 cm or 28 to 30 inches and in females it is about 66cm or 26 inches. From the above analysis we can say that the person having longer height has longer step length. Step length of a person varies depending on their way of movement viz. walking, running or strolling and it may be the limitations of gait analysis and in case of step width it varies from 3 cm to 4 cm or 1inch to 2 inch for all height ranges so it can be said that the step width of the person doesn't depends on the height as well as gender of the person [5]. From the above discussion about foot angle and step angle from the height range from 5 ft to 6ft it can be assumed that the foot and step angle is same in male and female and foot angle is half of the step angle. And the foot angle generally varies from 10 to12 degree and step angle varies from about 25 to 30 degree. Until person has not some abnormality like pregnancy or any muscle disorder.

Conclusion

All the above data is validate for person having normal gait behavior. There are some limitations with gait pattern so it may be questionable or it is a matter of consideration because there is some factor which affects gait in some extent like footwear, fatigue, speed, mood, lighting condition, pregnancy, profession like army, any clinical muscular disorder. But still In this research, a detailed analysis of gait pattern of 80 subjects in random population have been made and this research revealed variety of differences in walking pattern and clearly indicated the uniqueness of the individual gait patterns are identical. In the scene of crime examination, the investigating officer can very well apply this technique of gait pattern analysis which would yield many more information in the aspect of identification. Most of the investigators are ignoring it. And this data may play a very significant role in forensic science to identify or making profile of criminals.

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