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The identification of individuals by observational gait analysis using closed circuit television footage

Ivan Birch [a,*], Louis Raymond [b], Anastasia Christou [c], Milan Angelo Fernando [c], Nigel Harrison [b], Flo Paul [c]

[a] Sheffield Community Services, Jordanthorpe Health Centre, 1 Dyche Close, Sheffield, S8 8DJ, United Kingdom
[b] Ainsley Clinic, High Street, Rhuddlan, Denbighshire, LL18 2UA, United Kingdom
[c] School of Health Professions, University of Brighton, Robert Dodd building, 49 Darley Road, Eastbourne, BN20 7UR, United Kingdom

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ABSTRACT

This study investigated the ability of individuals with experience in gait analysis to identify people by observing features of gait recorded by closed circuit television cameras (CCTV). Seven experienced analysts each viewed five samples of footage. Each sample showed a "target walker" and five "suspect walkers." The task of the experienced analysts was to determine which, if any, of the "suspect walkers" was the "target walker." All of the participant "walkers" wore identical loose fitting clothing to mask anatomical and body contour features, and balaclavas to obscure facial features. The overall results showed that the experienced analysts made a correct decision in 124 of 175 cases (71%), significantly better than would have been expected to have occurred by chance ($p < 0.05$). A significant variation in correct decisions ($p < 0.05$) was shown to occur between the various angles from which the footage was recorded, footage recorded in the saggital plane showing the highest number of correct decisions. Significantly more correct decisions ($p < 0.05$) were also shown to occur when the footage of the "target walker" and that of the "suspect walker" were taken from the same angle. The results suggest that individuals with experience in gait analysis perform well in the comparative identification of suspects from CCTV footage, and therefore do have a role to play as expert witnesses in this field.

1. Introduction

With the rapid increase in the number of closed circuit televisions (CCTV) cameras in operation throughout the world, the likelihood of a perpetrator being filmed committing a crime has significantly increased [1]. As a consequence expert witnesses are frequently being called upon to offer their opinion as to whether a suspect, filmed after the event, is the same person as the one recorded carrying out the crime [2]. However, footage captured on CCTV is often not of the best quality. Reasons include the quality of the camera, environmental factors, lighting conditions and the angle of the recording. As a result key features such as the individual's face may be obscured and the footage deemed unusable for direct identification [3].

There has been increased interest in the use of gait as a parameter of identification, partly due to the fact that it can be employed when footage has been recorded at a distance, and when other strategies, such as facial recognition or fingerprints are not useable [3,4]. Despite the increasing use of this strategy, there remains a lack of substantive scientific evidence to support the notion that gait can be used as a means of identification.

Early studies by Cutting and Kozlowski [5] attempted to address this paucity of evidence by demonstrating that individuals can identify themselves and others from a dynamic display of their movements. While the results indicated that gait analysis could be used as a means of identification, overall correct responses occurred in only 38% of all trials.

Stevenage et al. [6] showed that the human visual system was sophisticated enough to identify individuals on the basis of their gait. They investigated whether or not inexperienced individuals could recognise the gait of an unfamiliar target from an array of 6 possibilities. Results showed that out of 48 participants, 24 were able to identify their target walker correctly, with 33 out of the 48 selecting a possible match of the same gender. Although the overall correct identification rate was only 50%, using chi-squared analysis they demonstrated that the results were significantly greater than would have occurred by chance alone.

In a more recent study Larsen et al. [2] concluded that although visual gait analysis was not 100% accurate, it could be used to identify an individual. Their evidence had been used to convict individuals in a court of law, a landmark case being Noerager 2004.

Many aspects of CCTV footage, including frame rate, resolution and the positioning of the CCTV camera relative to the subject being recorded, are likely to affect the usefulness of the footage in visual gait analysis. Nevertheless, little research has been conducted as to the confounding effects of these factors. The angle of recording is perhaps the most obvious of these factors and it is generally agreed that

* Corresponding author. Tel.: +44 1323 762724, +44 7970 047114 (mobile).
E-mail address: ivanbirch@btinternet.com (I. Birch).

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comparative analysis is hampered if the recorded footage has been filmed from a less than ideal recording angle [8]. However, what the ideal recording angle is, is still subject to debate [2,7,8]. Jokisch and Larsen agreed that images recorded in both the frontal and sagittal plane views would capture the most examinable features of gait [2,8]. However, Geradts [9] suggested that images captured in the frontal plane, combined with those captured from overhead would make it easier to identify a perpetrator by allowing transverse plane rotation and step length to be assessed.

The purpose of this study was to investigate the effectiveness of visual gait analysis as a means of identification.

2. Method

The study was approved by the School Research Ethics and Governance Panel, School of Health Professions, University of Brighton. Thirteen participants, matched for height and build, were recruited from the podiatry undergraduate course to take on the role of "walkers," 8 females and 5 males.

The exclusion criteria were as follows:

- no obvious pathological gait (including injury or walking aid).
- people who were unwilling to provide informed consent.

Thirteen prospective participants, each with a minimum of 5 years experience in observational gait analysis, were contacted to take on the role of the analysts, 7 of who participated in, and completed, the study. The participants who did not complete withdrew because of time constraints. The participants came from a range of professional backgrounds including podiatry, physiotherapy and biomechanics, and all undertook observational gait analysis as part of their professional practice. Although 3 of the participant analysts had had some engagement with forensic gait analysis, none were engaged in this area of work as their core professional practice. This mix of professional training and practice was considered to be representative of the range of individuals increasingly becoming involved in forensic gait analysis. All CCTV footage was captured at the Robert Dodd Building, School of Health Professions, University of Brighton, Eastbourne, England. Three Solidex KCCD200 dome cameras, connected to slimline solidex 4 channel DVR with USB ports (SCT ltd, Croydon, England) were used to record the footage of the participants walking at 15.625 KHz (50 KHz vertical and 420TVL horizontal resolution). The quality of the recorded footage produced was considered to be acceptable for identification purposes [2,8,9].

The walkers were provided with identical clothes (black jogging bottoms, a black hooded sweatshirt top, a black balaclava and black socks and gloves) in order to disguise their facial features and conceal their body shape.

Three CCTV cameras were used to capture the participants walking in the frontal plane, the sagittal plane, and from an oblique angle, providing enough data to assess the impact of recording angle on identification [2,8–10]. The walkers were instructed to walk back and forth along a 15 metre walkway in their normal manner. Recordings were taken once the participant had relaxed into a normal pattern of gait. The process took approximately 15 minutes per walker.

A total of 18 clips, each comprising of 4 seconds worth of footage, were selected for each walker, 3 from each recording angle and direction, providing a total of 234 clips. Five clips were randomly selected to become the "target walker." Twenty five additional clips were selected to represent the "suspect walkers," five for each target.

The selected clips were then formatted to AVI files in order to remove the time and date information, and the files embedded in a Microsoft 2007 PowerPoint presentation. Each slide of the presentation presented the viewer with a "target walker" and five "suspect walkers." When being viewed, each clip as was set to play in full screen mode. The completed presentation was copied onto a series of Panasonic 700mb CD-R compact discs.

The analysts were each provided with a CD ROM, together with full instructions and a data recording sheet. They were instructed to view each slide in the PowerPoint presentation and decide, for each slide, if any of the 5 "suspect walkers" was a match for the "target walker," recording their judgments as "yes" or "no" noting key features of gait that had aided them in making their decision. They were permitted to view the footage as many times and for as long as they wished. Pilot trials suggested that the task should take approximately 30 minutes. It was strongly emphasised in the instructions that identification should centre on observable parameters of gait and not on anatomical features and body contour.

The results from the data recording sheets were entered into a Microsoft Excel spreadsheet. One mark was awarded for each correct decision and no mark for an incorrect decision. The scores were totalled for each analyst and for all analysts. Analysts' observations were also tabulated to highlight the different parameters of gait used to aid in the identification process. Percentages were calculated to allow easy comparison.

3. Results

Table 1 shows that collectively the analysts were able to identify correctly whether or not the "suspect walker" was a match for the "target walker" on 124 out of 175 occasions (71%). Chi Square analysis showed this to be a significantly better rate of correct identification ($p < 0.05$) than would have been expected to have occurred by chance. Analyst 3 had the highest number of correct decisions scoring 20 out of 25 (80%). Sequence number 3 proved to be the most challenging for the analysts, producing an overall score of 20 out of 35 (57%). Sequence 5 had the highest number of correct decisions with 28 out of 35 (80%). On 33 out of 35 occasions (94%), the analysts were able to identify correctly that the "suspect walker" did not match the "target walker" when the suspect had a different gender.

Table 2 shows the number of correct decisions for each of the recording angles. Chi Square analysis showed the variation to be statistically significant ($p < 0.05$). The sagittal plane recording angle had the highest number of correct identifications, 22 out of 28 (79%), the rear frontal angle the lowest, 23 out of 35 (66%).

When the "target walker" and "suspect walker" were recorded walking from the same angle, the results showed 22 out of 28 (79%) correct decisions. When the "target walker" and the "suspect walker" were not recorded from the same angle this fell to 102 out of 147 (69%). Chi Square analysis showed this variation to be statistically significant ($p < 0.05$).

Table 3 shows the key features of gait that the analysts used to aid them in making a decision. Upper body features of gait were noted more frequently than lower body features. Almost all of analyst 3's decisions were made by observing upper body gait movements and this analyst scored the highest number of correct decisions, 20 out of 25 (80%). Analyst 5 who produced the lowest score of 16 out of 25 (64%,) predominantly used lower body gait features.

4. Discussion

The aim of this study was to investigate the ability of individuals with experience in observational gait analysis to identify people by their gait pattern, when viewing footage filmed on closed circuit television cameras.

The findings showed that individuals with experience in observational gait analysis are able to identify people at a frequency significantly greater than would have occurred by chance. Furthermore, the results, when compared to those of Stevenage et al. [6], suggest that analysts with experience perform better in the task than those without experience. The experienced analysts in this study had a correct identification score 21% higher (71% as opposed to 50%) than the inexperienced analysts of the study of Stevenage et al. [6].