Chapter

Guarding the Gait: Evaluating Forensic Gait Analysis Evidence

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Abstract

Novel scientific evidence challenges courts in terms of how they can evaluate reliability for the purposes of making admissibility decisions and assigning probative value to information that is adduced before them. An example of such problematic evidence is forensic gait analysis evidence which is in its infancy as a discipline of forensic science. This chapter reviews how objections to forensic gait analysis evidence have been handled in judicial decisions at first instance and on appeal in Canada, the United Kingdom and Australia. It identifies vulnerabilities in such evidence, especially when jurors are required to incorporate expert opinions (often from podiatrists) about the similarities in gait between that of the accused and a person seen on CCTV footage. The chapter expresses concern about the current scientific basis for such evidence in the absence of well developed databases in relation to gait characteristics, difficulties that characterise interpretation of CCTV footage, and the role that subjective issues can play in analyses by experts in gait interpretation. It notes a United Kingdom initiative in formulating a code of practice for forensic gait analysts but calls for caution in relation to reception and weight to be attached to such evidence until its scientific status becomes more developed.

Keywords: Novel scientific evidence, forensic gait analysis evidence, admissibility, probative value, weight, miscarriages of justice

1. Introduction

Forensic gait analysis is one of a number of novel areas of scientific evidence that have troubled the courts in recent years and led to conflicting curial decisions in relation to admissibility and probative value. In this regard it takes its place alongside facial mapping and body mapping evidence, psychological autopsy evidence, polygraph evidence, lip-reading evidence and ear print comparison evidence [1] as a form of evidence that carries the potential to appear to be more scientifically reliable than it is and therefore which carries a risk of misevaluation if not critically scrutinised. Such evidence is particularly problematic in criminal trials when verdicts are determined by lay jurors. This is because of the danger that decision-makers will invest overmuch trust in evidence that appears to be scientifically rigorous when it may not be [2].

Forensic gait analysis functions as an example of a dangerous category of apparently scientific evidence that is beguilingly probative but which has the potential to lead to miscarriages of justice. It challenges decision-making by courts and attempts by law reformers to formulate criteria for determining admissibility or at least indicia for safeguards so that misimpressions are not given about evidentiary reliability

which may lead to miscarriages of justice. Further, it raises questions about those who are prepared to hold themselves out as forensic experts in the area.

This chapter reviews the current status of knowledge about forensic gait analysis. It identifies significant judicial decisions about the area and it reflects on measures that need to be adopted to minimise the risks that inappropriate reliance will be placed upon problematic application of this form of evidence in criminal trials before it is developed further and acquires the attributes of scientific reliability.

2. Forensic gait analysis

Gait is the way in which a person takes steps when walking or running. It consists of a series of largely repetitive, cyclical movements that are generally symmetrical. It can be observed at a distance, without the knowledge of a person of interest and cannot easily be concealed or dissimulated. Gait analysis has been defined as 'the systematic study of human walking, using the eye and brain of experienced observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles' [3–5]. It can be undertaken by observations that a person is bow-legged or has knock-knees or a has a foot that points in or out. It can include consideration of the joints and segments of various parts of the body, including the hips. A variety of tools can be employed to enable calculation of lengths or angles.

Forensic gait analysis is the analysis of the style or manner in which a person walks, as applied to legal issues, including in the context of criminal trials. It has emerged as an important aspect of forensic podiatry, which has been defined as 'the application of sound and researched podiatric knowledge and experience in forensic investigations to show the association of an individual with a scene of crime, or to answer any other legal question concerned with the foot or footwear that requires knowledge of the functioning foot' [6–8]. The area of forensic gait analysis is an evolving and controversial area of scientific controversy [5, 9–12] that generally involves the use of closed circuit television ('CCTV') footage that can be of variable quality in which a comparison is made of a criminal perpetrator's gait with that of the accused. A number of judicial decisions on the issue of admissibility have been handed down, including on appeal in Canada (*R v Aitken*) [13, 14]; the United Kingdom (*Otway v The Queen*) [4], (*Hashi v The Queen*) [15] and Australia (*R v Crupi*) [16].

3. Canadian authority

In *R v Aitken* [13] the accused was charged with murder. There were no witnesses but the fatal shooting outside a Chelsea apartment was captured on the security CCTV positioned above the doorway to a building. Eighteen hours before the shooting CCTV also captured a person of similar size and stature as the shooter apparently canvassing the area and inspecting the buzzer system (the person of interest). The prosecution proposed to call persons whom it proffered as experts from two different but, it maintained, complementary disciplines.

The first expert was Hayden Kelly who held a degree in podiatric medicine and had been practising since 1987 in the United Kingdom. He had seen approximately 38,000 patients. In 2002 he became a podiatric surgeon. From 2006 to the time of the trial in 2008 he had been a researcher in forensic gait analysis identification at Barts College, which is part of the University of London. He had been consulted in approximately 150 legal cases and written over 50 expert opinions. He had testified in the English criminal courts over twenty times.

The second expert was Dr. Vernon Brugge who held a doctorate in biology and was held out by the prosecution as an expert in examining photographic evidence. He joined the Federal Bureau of Investigation as a forensic scientist who examined photographic evidence in the technological digital evidence laboratory in Virginia. He had given expert evidence in forensic image analysis, including photographic comparisons, photogrammetry, image and video authentication on some two dozen occasions. He had performed facial and clothing comparisons hundreds to thousands of times. Dr. Brugge's evidence included photogrammetric evidence and facial and clothing comparisons. In his work undertaking photographic comparison, Dr. Brugge compared features on an object or person depicted in a questioned image with a known image to identify or exclude from similarity, utilising 'class characteristics' -those that are common to a group or class of people - and 'individual characteristics' identifying characteristics that separate someone from the class.

Mr. Kelly described his forensic gait analysis procedure as having three steps:

1. He views video footage (or stills) of an individual to determine:

   a. If the quality of the film is sufficiently clear, and

   b. If there is a particularly distinctive gait or feature of gait shown.

2. If he finds distinctive features, then he views other footage of an individual(s) to see if the same features or gait exist;

3. Following that, the analysis is performed on a control, which is footage of a known individual(s) ([13] at [10]).

His view was that the person of interest, the shooter, and the accused shared a "very strong likeness" in that they all had 'very abducted left and right feet and an everted left foot' ([13] at [13]). He expressed the view that he 'would not expect to see this in more than one percent of the population. He did not observe anything in the material with which he was provided that suggested that the accused could not have been the person of interest or the shooter depicted in the videos ([13] at [13]). Thus his testimony amounted to identification of points of similarity and no points of dissimilarity.

Dr. Brugge used Photoshop techniques and a power point program to enhance and overlay known images on enhanced questioned images to detect similarities and differences. He compared still photographs from the video outside the Chelsea apartment where the murder took place with photographs of the accused. His evidence was he could not identify the accused as the person of interest or the shooter, but he could not exclude him either. Dr. Brugge could find no 'individualizers', such as scars, marks, moles, etc., that could lead to positive identification or exclusion of any of the individuals depicted in the photographs. Similarly, the clothing worn by the person of interest or the shooter bore no individual identifiers such as rips, tears or stains. The defence accepted that Dr. Brugge could testify as to how the video and video stills were processed to improve details by adjusting brightness and contrast and image enhancement but not the photographic comparisons.

Justice Satanove applied the Canadian tests in relation to expert evidence admissibility set out by the Supreme Court in *R v Mohan* [17], requiring establishment of:

1. Relevance;

2. Necessity in assisting the trier of fact;

3. The absence of any exclusionary rule; and.

4. A properly qualified expert.

She found the evidence of Mr. Kelly to have 'high probative value' in that it tended to establish a fact in issue, the identity of the killer ([13] at [19]). However, she concluded that Dr. Brugge's evidence was not admissible although she permitted his evidence on the technological enhancements he made to the videos and stills that were shown to the jury.

Justice Satanove accepted that: 'Evidence that is otherwise logically relevant may be excluded if its probative value is overborne by its prejudicial effect; if it involves an inordinate amount of time that is not commensurate with its value; or if it is misleading in the sense that its effect on the trier of facts, particularly a jury, is out of proportion to its reliability. There is a danger that expert evidence will be misused and will distort the fact-finding process. Dressed up in scientific language that the jury does not easily understand, and submitted through a witness of impressive credentials, the evidence may lie be accepted by the jury as being virtually infallible and, thus, given more weight than it deserves' ([13] at [19]). She observed that the potentially prejudicial effect of the experts' evidence may in their impressive credentials and their aura of infallibility ([13] at [19]).

Tellingly, she noted that Mr. Kelly drew a conclusion as to the degree of prevalence of gait characteristics in the general population 'that appears significant, yet lacks a scientific basis' ([13] at [23]). To address this risk, she allowed Mr. Kelly's evidence but not his opinion about the extent of abduction and eversion in the general population. However, Justice Satanove was not satisfied that Dr. Brugge's evidence was 'necessary', as that term is understood under Canadian law, namely that such evidence is outside the experience and knowledge of a judge or jury. She accepted that it may be '"helpful" as an experienced person's observation of facial features and clothing, but the jury will be able to form their own conclusions without this help. In my opinion, Dr. Vorder Brugge's comparison evidence does not offer any information outside of the purview of the ordinary jury, and therefore does not meet the test of necessity' ([13] at [24]).

She was not satisfied that the evidence of Mr. Kelly constituted "novel science": "podiatry has been in existence for a thousand years and the expertise of a podiatrist to analyze an individual's gait has long been accepted and practiced in a clinical setting. After carefully viewing the video frame by frame, many, many times, with his trained and practiced eye, he is able to point out fairly unique characteristics of the gait and stance of the individuals depicted in the video. The features are akin to individual identifiers to some extent. I do not think there is a danger of the jury being mesmerized by what is quite simply an exercise of expertise in observation and diagnosis" ([13] at [34]). The result was that Justice Satanove admitted the gait analysis evidence of Mr. Kelly, save the part which referred to a mathematically expressed degree of prevalence but excluded the evidence of Dr. Brugge insofar as it related to technological enhancements he made to videos and stills, but excluded his comparison evidence.

Cunliffe and Edmond [10] have criticised the ruling by Justice Satanove as an 'admissibility compromise. However, on appeal (*R v Aitken* [14]) the British Columbia Court of Appeal [14] upheld the decision at first instance to admit the evidence of Dr. Kelly. The Court applied the *Mohan* test formulated by the court in *R v Abbey* [18] at [80] where it was held that a trial judge must conduct a 'rule-based' analysis to assess compliance with preconditions to admissibility:

- the proposed opinion must relate to a subject matter that is properly the subject of expert opinion evidence;

- the witness must be qualified to give the opinion;
- the proposed opinion must not run afoul of any exclusionary rule apart entirely from the expert opinion rule; and
- the proposed opinion must be logically relevant to a material issue.

The Court of Appeal agreed with Justice Satanove that the evidence of Mr. Kelly was not 'novel' for the purposes of the *Mohan* test and concluded that his evidence fell into the category of 'specialized knowledge gained through experience and specialized training' ([14] at [80]). It held that this meant that there was no error in the trial judge failing to consider indicia of scientific validity such as peer review, rate of error and adherence to a scientific method – 'These factors have limited relevance in a case like the one at hand where a witness's expertise is gained over a period of years through observation and experience in the professional realm' ([14] at [80]). The Court of Appeal concluded that Mr. Kelly's evidence that there was a 'very strong likeness' in gait between the individuals shown on the video footage was 'merely a distillation of his factual observations, and that he did not usurp the role of the trier of fact by offering a conclusion on the ultimate issue of the identity of the shooter' ([14] at [84]). This meant that he was not breaching the preclusion on giving evidence on an ultimate issue but simply offering a piece of circumstantial evidence that narrowed the gap between who could be the shooter and the person of interest and the accused.

In important respects, the most contentious aspect of the Court of Appeal's judgement was its endorsement in the context of forensic gait analysis ([14] at [85]) of the comments of Justice of Appeal Doherty in *Abbey* ([18] at [92]):

> *… I doubt that the jury would have difficulty critically evaluating [the expert's] opinion. There was nothing complex or obscure about his methodology, the material he relied on in forming his opinion or the language in which he framed and explained his opinion. As when measuring the benefits flowing from the admission of expert evidence, the trial judge as "gatekeeper" must go beyond truisms about the risks inherent in expert evidence and come to grips with those risks as they apply to the particular circumstances of the individual case.*

The Court of Appeal found no error in the evidence of Mr. Kelly being placed before the jury to provide assistance in their evaluation of the images so that the jurors might utilise the knowledge acquired by Mr. Kelly through his training and experience in arriving at their own conclusions regarding the identity of the shooter ([14] at [86]). The Court of Appeal reviewed English decisions on the issue, including that of *Otway v The Queen* [6] (see below), which had been decided since the trial judge's decision, and classified them to be of persuasive authority and supportive of the admissibility of forensic gait analysis in the circumstances of what was before the Court.

While Cunliffe and Edmond [10] have been critical of the latitude extended by the trial and appellate decisions as to the admissibility of forensic gait analysis in the *Aitken* judgements, it is apparent that at both levels the courts regarded the evidence as having probative value which the jury was in an adequate position to evaluate. Therein lies the contentious and problematic aspects of the judgements in that the jurors had no statistical tool on the basis of which to evaluate the significance of the points of similarity identified by the expert and there was a risk of their attributing weight and giving deference to the evidence which was out of proportion to its probative value.

4. English authority

Although gait analysis evidence was permitted in the 1839 case of *R v Thomas Jackson* where the accused was identified by his bowed left leg and his propensity to walk with a limp, and was admitted in an armed robbery trial in the Old Bailey in 2000 in relation to a suspect said by a podiatrist to have a bow-legged gait encountered in only 5% of the United Kingdom population, (*R v Saunders*: see [5]), there are two major English appellate decisions in relation to gait analysis.

4.1 R v Otway

In *Otway v The Queen* [6], evidence in relation to walking gait analysis was adduced in a murder trial by the prosecution from CCTV images which depicted 20 seconds of an offender in motion. The driver and a passenger of a motor vehicle approached the deceased man and the passenger shot him dead. Otway was alleged by the prosecution to be the driver and was convicted on the basis of being participant in a joint homicidal enterprise.

The witness who gave the gait analysis evidence was a Mr. David Blake, who described himself as a 'podiatrist and specialist in lower limb gait, pathomechanics and biomechanics' ([6] at [10]). He said that he routinely used video camera equipment to analyse gait clinically to assess and diagnose anatomical and skeletal conditions. He described the practice of gait analysis ([6] at [10]) as follows:

> *Gait analysis is the examination of walking or running. The gait, or walking cycle, skeletal movement in general can have recognised anatomical movements or reference points during a walking cycle. Biomechanics is the examination and analysis of body movement. Specifically in this case to humans the skeleton can at times give an anatomical signature that if not unique, can be a relatively rare anatomical position or movement to a few individuals. A person's walking cycle or his skeletal anatomy is difficult to hide as it is part of their body's anatomy. The science of gait analysis was introduced into the UK and the profession of podiatry in the early 1970s. The gait cycle can be broken down into factors such as the position of feet and other parts of the lower limb. Thus features of gait can be identified and sometimes quantified. Podiatrists use gait analysis virtually every day in their practice. Recently that science has been applied forensically. The Council for the Registration of Forensic Practitioners recognises gait analysis and footprint identification as important components in identification of individuals. A podiatric section has recently been set up ... some clinicians may suggest that certain key elements of gait cycle or biomechanical (body) position and movement can leave a unique signature confirming that an individual in comparison is one of the same ...*

Mr. Blake stated that he saw approximately 2,000 patients per year in his practice as a podiatrist and that it was highly unusual to see a skeletal structure that has a linear spine without some scoliosis or lordosis, namely one form or another of curvature. He concluded that Otway, in common with the driver of a motor vehicle observed on CCTV, had an unusually erect posture. Mr. Blake estimated that only in about 7% of his practice population did he find 'the slight neck flexion or head poke where the head is projected excessively forward' which he observed in the recordings of the offender and of Otway.

At trial it was argued for the defence that the analysis offered by Mr. Blake could be undertaken by the jurors themselves unassisted by expert evidence ([6] at [11]) and that there was no statistical database against which the jury could judge the

significance of his evidence. In addition, it was contended that there was no scientific basis, and no measurement, to support Mr. Blake's methodology. The trial judge ruled that Mr. Blake should be permitted to give evidence in which he identified the similarities between the walking gait of the appellant and the walking gait of the suspect. It was for the jurors to assess that evidence having viewed the recorded material for themselves. Mr. Blake, however, was not permitted to give evidence relating to the facial features of the appellant or the suspect, and was not permitted to evaluate his comparison of walking gait by reference to the chance that the driver of the motor vehicle at the petrol filling station was someone other than the appellant.

The Court of Appeal received evidence from a professor who was an expert in biology and genetics and who argued that there was an absence of evidence about whether the technique employed by Mr. Blake had been tested in field conditions, subjected to peer review and publication or known rate of error, or subjected to verifiable standards. The Court of Appeal observed that the professor was not a podiatrist and not in a position to express an opinion as to whether Mr. Blake had the expertise which he purported to employ in his analysis. It observed too that in *Re T* [19] at [92]–[96], Thomas LJ giving the judgement of the court, made reference to several cases in which, by reason of the subject matter of the expert evidence, the expert was unable to evaluate their findings by reference to a database of random selection:

> *Nevertheless the evidence of evaluation, founded upon and explained to be the consequence of personal experience, was properly admitted. The proposition that evidence of a comparison cannot be admitted if its evaluation is expressed in terms subjective experience is simply wrong in law (at [20]).*

The Court of Appeal applied the reasoning in *Atkins & Atkins*, a case involving facial mapping evidence in which ([18] at [23]) Lord Justice Hughes stated:

> *An expert who spends years studying this kind of comparison can properly form a judgement as to the significance of what he has found in any particular case. It is a judgement based on his experience. A jury is entitled to be informed of his assessment. The alternative, of simply leaving the jury to make up its own mind about similarities and dissimilarities, with no assistance at all about their significance, would be to give the jury raw material with no means of evaluating it.*

It noted the words of Lord Justice Rose in the 2004 decision of the English Court of Appeal in *R v Luttrell* [21]:

> *"32. For expert evidence to be admissible, two conditions must be satisfied: first, that study or experience will give a witness's opinion an authority which the opinion of one not so qualified will lack; and secondly the witness must be so qualified to express the opinion. The first was elucidated in Bonython [1984] 38 SASR 45, where King CJ (at p.46) said that the question "may be divided into two parts: (a) whether the subject matter of the opinion is such that a person without instruction or experience in the area of knowledge or human experience would be able to form a sound judgement on the matter without the assistance of witness possessing special knowledge or experience in the area, and (b) whether the subject matter of the opinion forms part of a body of knowledge or experience which is sufficiently organised or recognised to be accepted as a reliable body of knowledge of experience, a special acquaintance with which by the witness would render his opinion of assistance to the court.*

> *33. If these two conditions are met and the evidence of the witness is admissible, although the weight to be attached to his opinion must of course be assessed by the tribunal of fact: Robb [1991] 93 Cr App R 161, 165; Darragher [2002] EWCA Crim 1903, [2003] 1 Cr App R 12 para 23 ... It might added that, as with any evidence, expert testimony will not be admitted unless it is relevant in the sense that "it is logically probative or disapprobative of some matter that requires proof": per Lord Simon in Kilbourne [1973] AC 729, 756 D.*
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> *34. As we have indicated, the appellants argued that evidence should not be admitted unless it passes a certain test, that the evidence can seen to be reliable because the methods used are sufficiently explained to be tested in cross-examination and so to be verifiable or falsifiable. Where, as here, the Crown is seeking to adduce the evidence in a criminal trial, this could properly be considered by the court when deciding whether to refuse to allow the evidence, under Section 78 of the Police and Criminal Evidence Act 1984 or otherwise, in order to ensure a fair trial. We cannot accept that this is a requirement of admissibility. In established fields of science, the court may take the view that expert evidence would fall beyond the recognised limits of the field or that methods are too unconventional to be regarded as subject to the scientific discipline. But a skill or expertise can be recognised and respected, and thus satisfy the conditions for admissible expert evidence, although the discipline is not susceptible to this sort of scientific discipline..."*

Ultimately, the Court of Appeal in *Otway* upheld the trial judge's conclusion that the evidence of Mr. Blake, in the absence of contradiction, was sufficient to establish the existence of (1) the science or expertise; (2) the witness's proficiency in it; and (3) the foundation for the witness's opinion. It accepted ([6] at [22]) the argument that:

> *in a comparison exercise based upon facial mapping or walking gait, it is a necessary condition of admissibility that the witness is able to demonstrate to the court the features of comparison upon which his opinion is formed. Since the comparison is visual, an inability by the witness to explain and demonstrate the features upon which his opinion is formed not only places in doubt the existence of the science or technique claimed; it undermines the foundation of reliability required. We have read a transcript of Mr. Blake's evidence and we have viewed the recorded material from which he demonstrated the foundation for his opinion. We entertain no doubt that the jury was in a position to follow and assess the value of his evidence. There is no danger here that the jury was being invited simply to take Mr. Blake's comparison on trust. We agree with Maddison J, however, that Mr. Blake's ability safely to express his ultimate conclusion in terms of probability of a match, even probability based on Mr. Blake's clinical experience, was insufficiently established. It is important that juries are not misled to an over-valuation of comparison evidence.*

While the Court declined leave to appeal, it was circumspect in its expression of its reasons and concerned not to be seen to be accepting of this novel form of evidence ([6] at [23]):

> *We do not wish it to be thought that we are endorsing the use of podiatric evidence in general. Upon the evidence before him and the argument addressed to this court, we conclude that Maddison J was right to rule the evidence admissible. However, each such application must be considered on its own merits. It may well be, as in the present case, that the trial judge will need to be astute when such evidence is admitted that it is strictly confined within the expertise established and that the*

> *proper limits of evaluation are identified from the outset. We endorse, with respect, the views of the court in T (paras 97–99) as to the necessity for the parties to have issues of disclosure and admissibility well in mind during preparation for the case management hearing so that, when the appropriate time comes, the trial judge is presented with all the material needed to make an assessment of admissibility, and the permissible scope of the evidence if admitted.*

4.2 Hashi v The Queen

In *Hashi v The Queen* [15] a ground of appeal arose from the fact that the prosecution had been permitted to rely upon the evidence of a consultant podiatric surgeon, Mr. Barry Francis, in relation to the similarity of the walking gait of the accused and that of a suspect. He had identified two distinctive aspects of gait – features which he described as an abnormality in the position of body parts in the walking cycle, and flow pattern, which he viewed as a product of the walking cycle, such as its speed or length of stride.

Mr. Francis found six common features between the gait of the suspect and the accused:

1. On the left side the toe was turned inwards;

2. Knee-knock;

3. The stance was upright without head-poke (that is, without the head being thrust forward);

4. There was a long stride with ankle movement in the stride;

5. There was a narrow base of gait (that is, the legs passed close together in the stride);

6. When the suspect turned, he did so from the waist rather than the neck ([15] at [56]).

Of these features the most prominent was the turning inwards of the left foot. Mr. Francis looked for any dissimilarities between the features of the walking gait of the suspect and the accused man in the recordings and found none. He stated that there was no database against which he could make an assessment of frequency and could only refer to his own clinical experience. This led him to express the view that the left-sided inward turn would be found in under 5% of the population. In his view it could only be caused by injury or by one-sided hypermobility, itself an unusual trait. In the absence of trauma, Mr. Francis stated that he would expect to see knee-knock in less than 10% of the population. He stated that there was no predisposition to the presence of one factor in the presence of the other – they were unconnected so it followed that 'a combination of features was more significant than the presence of any one of them ([15] at [57]).

Hashi relied upon the expert evidence of Mr. Blake, the expert who testified in *Otway.* At the relevant time Mr. Blake was the principal podiatrist at the Nuffield Hospital. His view was that the benchmark material was of insufficient quality to attempt an analysis of walking gait.

The Court of Appeal was provided with background material, including published material in relation to the effect of frame rate on the ability to identify

characteristics of gait from CCTV [22] and a Home Office Manual [23] in relation to the screen height on CCTV necessary to discern characteristic detail. It noted that at trial no challenge was made to Mr. Francis' evidence, notwithstanding the view of Mr. Blake. The argument was mounted, though, that Mr. Francis' evidence was unreliable because:

1. he provided his opinion 'in a manner that was overconfident having regard to the material on which it was founded';

2. the material itself was inadequate for the purpose of identifying features of gait;

3. the expert was not qualified to make the 'allowances' he claimed to be able to make and was unable to explain what allowances he had made; and

4. the value of the evidence was overstated by references to population ([15] at [73]).

The Court of Appeal accepted that the quality of the CCTV images 'is at times indifferent' and that care is required to ensure that the feature demonstrated is reliably demonstrated ([15] at [74]). The Court did not accept that Mr. Francis' inability to specify in scientific terms how he made allowances for an imperfect image rendered his opinion unreliable or unsafe:

> *He and the jury were viewing moving and still images. Mr. Francis was showing to the jury the images in which he saw features of gait and either those features could be seen by the jury or they could not. The jury was directed that they could act on the presence of features only if they could observe the features for themselves. Mr. Francis was saying that he had taken account of the imperfection in the image before declaring his identification of a feature. He showed the jury the image on which he relied to make the identification. He was not saying that, although the feature might not be seen by the jury, he, relying on his expertise, was sure it was present. In any instance in which it was argued that the quality of the image was insufficient to be sure that the feature was present the jury had the means to make the assessment for themselves with the assistance of the evidence of Mr. Blake and the cross-examination of Mr. Francis ([15] at [74]).*

This led the Court of Appeal to conclude that with appropriate judicial instructions the jurors could follow the evidence, evaluate its cogency and make their own decision as to whether the features demonstrated were present in each of the recordings. The Court did not agree with the argument that Mr. Francis should not have been permitted to refer to the frequency with which the features or abnormalities he found in the recordings occurred in the course of his clinical practice: 'It was for the jury to evaluate Mr Francis' evidence in the light of the criticisms levelled at him ([15] at [74]). Thus, it concluded that it was not necessary for the judge to have withdrawn the case from the jury at the close of the prosecution case – 'The jury had been provided with the tools with which to make that assessment: in the case of each image on which Mr Francis relied they had their attention drawn to the factors relevant to it, in particular to the quality of the images and the time lapse by which they were recorded. Mr Francis was closely cross-examined on each feature and each significant image' ([15] at [75]).

Both the *Otway* and *Hashi* decisions by the Court of Appeal determined the forensic gait analysis evidence to be admissible and that the risk of inappropriate

juror deference to the evidence was sufficiently addressed by judicial instructions. This was in spite of the evidence in *Hashi* that bore a numerical component of the frequency of the particular attributes in the population seen clinically by the expert. Both decisions were made prior to the intrusion of a reliability prerequisite into English criminal law [2].

5. Australian authority

The most significant Australian authority on forensic gait analysis is the 2020 ruling by Justice Beale in the murder case of *The Queen v Crupi* [16]. Part of the evidence suggesting that Crupi was the murderer was forensic gait analysis evidence given on this occasion not by a podiatrist but by Professor Marcus Pandy, the Chair of Mechanical and Biomedical Engineering at the University of Melbourne. He viewed 95 CCTV clips and was asked to identify and document any physical characteristics viewed in them. He measured certain spatio-temporal features of the gait of the subjects using a Google Earth measurement tool – step length, step frequency and walking speed. He found the step lengths of the subjects were consistently around the same value. In his first report he did not express any opinion as to whether or not the subjects of the clips were the same person but concluded that the mean step length and mean walking speed of the subjects were more consistent with the persons being elderly, as was the degree of toe-out gait – the relevance of this to the prosecution was that Crupi was aged 67 at the time of the murder.

On the basis of the first report by Professor Pandy, he was asked to offer a further opinion as to whether 'a person recorded in any of the CCTV footage contained in clips 1 to 36 is the same as a person recorded in any of the CCTV footage contained in clips 37 to 95'. Police also provided more precise measurements between various geographical features shown in the clips so that Professor Pandy could calculate the relevant spatio-temporal gait features of the subjects more accurately, rather than relying on the Google Earth measuring tool. Professor Pandy concluded that the subjects walked with a gait pattern 'more consistent with that exhibited by older adults, who take shorter steps and walk more slowly than healthy young adults' (at [26]).

The cross-examination of Professor Pandy proved important. He disavowed being an expert on whether persons were similar or dissimilar and said he had never done any research regarding the pitfalls in making such a comparison. He said he was not familiar with the concept of confirmation bias ([16] at [29]). Professor Pandy said he was not a statistician but had sufficient knowledge of statistics to calculate standard deviations. He said there was no way of assessing whether the subjects in any of the clips were walking at their preferred speed and agreed that sometimes he had had to round down the number of steps taken between the relevant locations. He also conceded that he sometimes had to make a judgement as to when a subject's heel struck the ground ([16] at [32]) and that the subjects did not always walk in a straight line between the points. He sometimes observed excessive lateral movement in the gait of the subjects ([16] at [33]).

Professor Pandy said he had never previously been asked to compare CCTV clips of subjects, that he knew nothing about the make or model of the CCTV cameras capturing the relevant images or whether they distorted the images. He conceded he had no information about the frame rates of the CCTV clips and agreed that the frame rates could affect the accuracy of his judgements as to when the heel of the subjects struck the ground (at [34]). Importantly, Professor Pandy was not able to shed any light on the statistical significance of his findings compared with the population at large, and did not purport to do so, instead stating that the mean step lengths of

the subjects in the two groups of clips were 'remarkably similar' ([16] at [35]). He refrained from attributing any specific age estimate to the subjects.

He observed that both feet of the subjects exhibited toe-out gait, although he did not make measurements of it. He stated that it appeared greater than normal for healthy young adults but he did not know the prevalence of a greater than normal toe-out gait in the community ([16] at [37]).

Justice Beale declined to admit the evidence of Professor Pandy. He reviewed the relevance of the evidence by evaluating the potential for a jury to have rationally accepted the reliability of Professor Pandy's calculations. He noted the defects in his evidence about 'rounding-offs' and observed that they may have been concentrated in one group (at [85]) and noted too that Professor Pandy had conceded that the CCTV frame rates, about which he said he knew nothing, may have affected the accuracy of his subjective judgements. He was troubled too that Professor Pandy used the time stamps on the CCTV clip to make his calculations but did not check the accuracy of the various stamps for the various CCTV cameras, as well as the fact that the subjects did not always walk in straight lines between points A and B and that at times there was excessive lateral movement by the subjects. He agreed with the submission from the prosecution that none of these matters may have significantly affected the accuracy of Professor Pandy's calculations but found that 'there is no way of knowing whether that is the case' (at [86]). That led Justice Beale to conclude: 'If the jury is to act rationally, there must be a proper basis for the jury to conclude that the accuracy of his calculations were not significantly affected by these matters. The evidence fails to provide a proper basis for such a conclusion' ([16] at [86]). He was also troubled by what he described as the difficulty of concluding rationally that Professor Pandy was 'comparing apples with apples':

> *He conceded in cross-examination that there was no way of knowing whether the subjects in clips 1–95 were walking at their preferred speed. And yet he based his opinion that the subjects had gait patterns more consistent with older persons primarily on a comparison of the data with results obtained in gait studies of young and old adults whom it was known were walking at their preferred speed ([16] at [87]).*

These issues led him to rule that the evidence of Professor Pandy failed the relevance test under s55 of Australia's 'uniform evidence legislation' and this made it inadmissible. The test in this regard was whether it had the potential to rationally affect the existence of a fact in issue between the prosecution and the defence.

In addition, Justice Beale was at pains to identify the area of specialised knowledge that the prosecution was seeking to adduce. He concluded that it was 'forensic gait analysis of subjects recorded on CCTV footage', this descriptor ultimately being important. He found that the fact that Professor Pandy conceded he was a novice in relation to the task of comparison – whether any of the subjects were the same – and also the CCTV aspect was significant. Professor Pandy conceded that had never undertaken gait analysis using CCTV recordings ([16] at [94]). Justice Beale found Professor Pandy's failure to discuss dissimilarities of gait to be a significant omission in his evidence and that it called into question his expertise to undertake comparative gait analysis. In addition, Justice Beale emphasised that Professor Pandy had conceded that it was the first time that he had conducted forensic gait comparison of subjects recorded on CCTV footage – 'it is difficult to see how Professor Pandy can be considered an expert in that field when this is the first time he has performed the task. For all his undoubted learning and experience,

I am not satisfied that Professor Pandy is an expert in the relevant area of FGA ([16] at [97]). Thus, he found that even if Professor Pandy's evidence passed the test of relevance, it engaged the exclusionary opinion rule ('Evidence of an opinion is not admissible to prove the existence of a fact about the existence of which the opinion was expressed': s76) and was not saved by the exception for opinions based on specialised knowledge (s 79).

Significantly too Justice Beale found that the evidence by Professor Pandy constituted tendency evidence:

> *First, clips 1–36 and 95 show D walking. Second, Professor Pandy's analysis of D's gait in those clips shows that D has a tendency to walk a certain way. Third, because D has such a tendency, he can be expected to walk that way on other occasions. Fourth, clips 37–94 show the shooter walking. Fifth, the way he walks is closely similar to the gait tendency exhibited by D. Taken together, the evidence of D's gait tendency, and its close similarity to the shooter's gait, support P's case that D was the shooter ([16] at [103]).*

This meant that it engaged the exclusionary rules in s97 of the uniform rules of evidence in Australia, requiring evidence to have significant probative value to be admitted. He found that it did not and therefore it constituted inadmissible tendency evidence.

Justice Beale also considered whether the evidence, if it was relevant, which he had found it was not, should be excluded on the basis that its probative value was outweighed by the danger of its constituting evidence that was unfair to the accused. He concluded that the probative value of his evidence was modest because, taken at its highest, it was evidence of similarity, not identity ([16] at [118]). In addition:

> *there is no evidence as to how common or uncommon in the general population are the mean step length, step frequency and walking speed of the subjects in the clips. Further, Professor Pandy does not assert that the subjects of the relevant clips are elderly, just that the spatio-temporal gait features are more consistent with the gait of older persons ([16] at [118]).*

Justice Beale identified two ways in which Professor Pandy's evidence had the potential to be misused – by the jury attaching more weight to it than it deserved, especially in light of his using the phrase, 'remarkably similar' and by reason of the jury engaging in tendency reasoning, a risk that he considered 'very real.' This led him to exclude the evidence as more prejudicial than probative.

6. The Chartered Society of Forensic Sciences and the College of Podiatry Code of Practice

Importantly, in 2020 the Chartered Society of Forensic Science and the College of Podiatry [24] published a 'Code of Practice for Forensic Gait Analysis'. It stipulated that the method used for the preliminary assessment in forensic gait analysis should include assessment of fact such as (but not limited to):

1. distortions of the image inherent in the footage;

2. the resolution (sharpness), lighting and frame rate of the footage;

3. the locomotor activity being undertaken by the figure/subject;

4. the number of consecutive mid gait steps seen in the footage;

5. the position of the camera relative to the figure/subject;

6. the direction in which the figure/subject is moving relative to the camera;

7. the relative size of the image of the figure/subject in the field of view;

8. the possible impact on gait associated with the figure/subject's footwear or lack of footwear; and

9. the possible impact on gait associated with the figure/subject's environment.

The Code also stated that features of gait should only be compared if the locomotor activity being undertaken in the questioned footage is the same as that being undertaken in the reference footage – walking footage should be compared with walking footage. The comparison should consider features of gait that:

a. are exhibited by both the figure in the questioned footage and the subject in the reference footage;

b. would preclude the figure in the questioned footage from being the subject in the reference footage;

c. are exhibited by the figure in the questioned footage, but not the subject in the reference footage, but do not preclude the figure in the questioned footage from being the subject in the reference footage; and

d. are exhibited by the subject in the reference footage, but not the figure in the questioned footage, but do not preclude the subject in the reference footage from being the figure in the questioned footage.

In addition, the Code of Practice ([24] at [18.63]–[18.68]) stated that:

- A database can be used to assist in the determination of the strength of evidence by the forensic gait analysis; however, its admissibility may be questioned if the database does not meet all of the following criteria:
  - ○ It is available for use by both the prosecution and defence.
  - ○ States the size of the population used.
  - ○ States the appropriateness to the case of the population used.
- The likelihood of such a database being deemed admissible may be boosted if:
  - ○ it is also in the public domain; and/or
  - ○ has been peer reviewed and published.

- If a database has been used to assist in the determination of the strength of evidence provided by the forensic gait analysis this shall be made clear in the final report, and the database identified.

- In the absence of the use of a database the final report shall contain a statement to the effect that the determination of the strength of evidence provided by the forensic gait analysis is an opinion based conclusion, and is not predicated on numerical data or statistical calculation.

- Where the expert provides an opinion based solely on their experience it is important that the statement make clear, in detail, the experience which allows the expert to proffer that opinion.

- The strength of evidence provided by the forensic gait analysis should be expressed using a published scale of verbal expressions of strength of evidence in support of one of two opposing propositions. Generally, the prosecution's proposition would take the form of 'the figure in the questioned footage is the subject in the reference footage'. The alternative proposition is determined by the defence but in the majority of cases takes the form of 'the figure in the questioned footage is not the subject in the reference footage'.

The Code of Practice for Forensic Gait Analysis is not binding outside the United Kingdom but it constitutes a sound articulation of responsible practice in a period when the area of forensic gait analysis is moving toward a sounder scientific basis.

7. Status of gait analysis evidence

For the present the area of forensic gait analysis poses significant risks in terms of its reliability and the danger that it will be invested with greater respect than its current scientific status deserves in light of the subjectivity inherent in most of its evaluations and the absence of rigorous databases which might enable a statement of the statistical significance of any finding of similarity.

In addition, it is significant that the quality of CCTV footage varies considerably. This can affect the ability of forensic gait analysts to undertake their evaluations informedly. For instance, frame rates on CCTV footage vary markedly, from one frame every 4 seconds to 25 frames per second. The work of Birch et al. [22] has shown that this variation has a major impact upon the ability of even experienced professionals to identify characteristics of gait with accuracy. While they have commented that, 'Every effort should therefore be made to ensure that CCTV footage likely to be used in criminal proceedings is captured at as high a frame rate as possible' ([22] at 169), this has not resolved the point at which such analysis ceases or commences to be reliable. A further issue potentially affecting such capacity goes to the extent to which the figure targeted occupies screen height [23].

Lynnerup and Larsen [25] have contended that: 'exact photogrammetric measurements may be made from CCTV material of perpetrators and at the scene of the crime, but that care must be taken to ensure that error ranges, especially connected to measuring the human (clothed and masked) body in motion, are critically estimated and evaluated.'

The decisions in the Canadian *Aitken* case and the Court of Appeal decisions in *Otway* and *Hashi* have extended significant and problematic latitude to forensic gait

analysis evidence, regarding the area as one of expertise and sufficient to enable jurors to utilise it as part of their task of evaluating for themselves similarities in different forms of footage of a person of interest and the accused. The ruling by Justice Beale in the Australian case of *Crupi* stands as a contrast to these authorities with his Honour being disinclined to permit opinion of 'remarkable similarity' on multiple bases including relevance, whether the expert was an expert in the relevant area, its constituting tendency evidence, and its being more prejudicial than probative.

A 2017 report by the Royal Society and the Royal Society of Edinburgh, in conjunction with the Judicial College, the Judicial Institute and the Judicial Studies Board for Northern Ireland ([5] at p6) supported the more cautious approach embraced by Justice Beale, warning that:

> *Its underpinning science is sparse and largely translated from the more developed fields of clinical gait analysis and biomechanics, with more recent insights from biometrics. Care is required, however, in assuming that techniques developed in one field can be applied in another with quite different objectives. The scientific evidence supporting forensic gait analysis, as currently practised, is thus extremely limited.*
> *When forensic gait analysis is used as an aid to positive identification of a suspect, the following matters should be borne in mind:*
> *There is no evidence to support the assertion that gait is unique within current or foreseeable limitations of measurements used in forensic gait analysis.*
> *There is no credible database currently that permits assessment of the frequency of either normal or abnormal gait characteristics.*
> *There are no published and verified error rates associated with the current methodology.*
> *There are no published black-box studies of analyst reliability and repeatability.*
> *There is no standardised methodology for analysis, comparison and reporting of gait characteristics.*

Cunliffe and Edmond [10, 26] have been particularly concerned about the current state of the art of forensic gait analysis and of forensic podiatry in general. They have argued powerfully that for the present the evidence is inherently unreliable and urged application of stringent tests to exclude it in most cases from jurors' consideration. They have contended ([24] at 279) that it

> *might be useful as a technology capable of assisting with identification or exclusion. This, however, assumes that technical problems associated with validation, image quality, duration of view, frame rates, different types of movement (e.g., walking, running, dancing, carrying objects, moving with injuries, moving while intoxicated, trying to disguise gait, or walking toward somebody with the intention of shooting), frequency and interrelatedness of features, and cognitive bias can be overcome. As things stand, forensic gait analysis can merely suggest that a person could be included within a set of similar persons where the apparent or alleged similarities are of unknown frequency, so the size of the set is unknown.*

Van Matrigt et al. [11] have correctly identified that: 'To improve clarity on admission of gait as evidence and assessing its evidential value, method validity and reliability and expert proficiency should be reported', a position supported by Cunliffe and Edmond. Van Matrigt et al. [11] have also argued that forensic gait analysts should:

> *join forces to create an international standard forensic gait analysis method with known validity, reliability and proficiency tests. We propose to focus on designing and publishing on large (inter)national gait databases and methods for likelihood calculation taking into account interdependent features. We also hope for (inter) national guidelines for the admission of forensic gait analysis in court. This is especially important since forensic gait analyst is not a protected professional title.*

Macoveciuc et al. [27] have emphasised the increasing role of digitisation of matching procedures within forensic podiatry and usefully argued that: 'A collaboration should be established between the gait analyst and the biometric specialist where the analyst inputs their own expertise to assess the match concluded by the biometric system and also advises (from a clinical and forensic perspective) on the data collection procedures and algorithm development.'

While forensic podiatry in particular and forensic gait analysis have enthusiasts [28] and have the potential to provide assistance to investigators and potentially to the courts, the harder question is as to the appropriateness of forensic gait analysis as expert opinion evidence until further development in the discipline takes place. Undeniably, there are risks in the subjectivity of the comparison process which has the potential to be distorted by cognitive and contextual biases. There is an urgent need for the development of relevant databases so that subjective identification of what is unusual, out-of-the-ordinary or remarkable can be contextualised objectively and, in particular, numerically [29]. Work in this regard has commenced but as yet has some distance to travel. It remains to be seen whether the area remains the principal preserve of forensic podiatrists and whether medical practitioners have a constructive contribution that they can make to its development. In all probability, though, as in a number of areas of forensic science, contributions can be made by practitioners from diverse disciplines, including biometric experts and forensic statisticians, to evaluate the accurate interpretation of results.

For the present what needs to be observed is that there are real questions about the probative value of most forensic gait analysis evidence, that expert evidence in respect of comparison of images needs to be undertaken with temperance and circumspection and that the prejudicial value of such evidence needs to be subjected to rigorous evaluation, including by reference to the Code of Practice for Forensic Gait Analysis published in 2020 by the Chartered Society of Forensic Science and the College of Podiatry [24] to determine whether it should be admitted in criminal trials.

Conflict of interest

The author declares no conflict of interest.

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