

<b>Institution:</b> Middlesex University		
<b>Unit of Assessment:</b> 24 – Sport and Exercise Sciences, Leisure and Tourism		
<b>Title of case study:</b> Changed behaviour in elite sport practice through performance analysis interventions		
<b>Period when the underpinning research was undertaken:</b> Sep 2010 – Dec 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b> Nic James	<b>Role(s):</b> Professor	<b>Period(s) employed by submitting HEI:</b> Sep 2010 - present
<b>Period when the claimed impact occurred:</b> Sep 2010 – Dec 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<b>1. Summary of the impact</b>		
<p>Integration of our performance analysis-based research within National and International coaching processes in Olympic and Paralympic teams led to the introduction of new data capture, analysis and visualisation methods that helped transform the impact of data driven feedback. The impact of these performance analysis interventions led to the provision of better feedback to practitioners, coaches and players and transformed training and match day performance through work with the English Institute of Sport (EIS), UK Sport, elite teams in New Zealand (High Performance Sport, NZ (HPSNZ)), squash (England National squads and elite players), tennis (LTA) and rugby (Ireland RFC). This resulted in improved preparation and performance of athletes competing at the Olympic and Paralympic games (Rio 2016), Commonwealth games (Glasgow 2014, Gold coast 2018) and the Rugby World Cups (England 2015, Japan, 2019).</p>		
<b>2. Underpinning research</b>		
<p>The research underpinning this case study is based upon an understanding of how small changes in elite performance can have dramatic effects and attention to fine detail is crucial to making champions. Whilst elite coaches make decisions on performance, the performance analyst enhances this by presenting performance in a visual way, underpinned by strong science, allowing patterns to be seen, systematic reviews of opponents and other performance related tasks undertaken, improving the use of coach's available time. Our research has been developed over many years, using a research method that actively forges relationships with professional teams who want novel data capture and analysis techniques to improve training and match performances. To develop this approach, initial research was carried out in collaboration with the EIS, working with the English Squash team (2010 – 2017) and then GB Canoe Slalom (2012 - 2016).</p> <p>Research work with England Squash (supported by studentships from EIS) was initially concerned with <b>profiling future opponent's playing styles</b> with a view to developing better playing strategies against them. This research, led by Prof James at Middlesex University, in collaboration with UK (Prof Hughes) and International researchers (Dr Vučković, Dr Perš) devised a new methodology for data capture that recorded movement using a computer vision background elimination technique, and shot data manually transcribed, on a novel 15 cell court [R1]. This new methodology allowed contextual variables, including availability of time, shot type and location, as well as information relating to the previous shot, to be analysed, within a multi-factorial model, hence providing situationally specific information related to playing patterns. This methodological approach, appropriate for, and used in other sports (football, rugby union, tennis, padel, dancesport), also allowed future specific questions to be answered such as how tactical shot selection had changed as a consequence of rule changes [R2]. Over time, future refinements in the research were implemented to answer more specific questions raised by England Senior Squash coaches. The culmination of this work involved assessments of tactical shot selections using a two-step cluster analysis, to better understand the factors affecting decision-making. This research demonstrated both consistency and variability for different shots in different court locations primarily due to the availability of time but didn't account for individual player differences [R3]. To contextualise this finding for individual player preparation a case</p>		

study of the top 2 players in the world was undertaken to determine the extent to which tactical shot selections vary within players as a consequence of the standard of their opponent [R4].

Further research was undertaken by Prof James and colleague (Dr Bryant) through the development of consultancy services for different Olympic sports (athletics, badminton, canoe slalom, cycling, fencing, gymnastics, hockey, judo, modern pentathlon, sailing, taekwondo, triathlon) and Paralympic sports (boccia, para swimming, wheelchair rugby) for the EIS, as well as the Ireland Rugby Union team, the Lawn Tennis Association and Leicester City FC. Additional research was undertaken (supported by studentships for EIS) to evaluate “what” the performance analysts, working for the EIS, were delivering to GB Olympic and Paralympic coaches [R5]. This research highlighted the importance of understanding the communication processes between analyst and coach, particularly during coach planning sessions. Research was also pursued to identify best practice for dissemination and the effectiveness of the PA delivery [R6]. Questionnaires and open-ended questions elicited training goals, athlete discussion, coaching philosophy and availability of time to be the factors most affecting the provision of video feedback, performance reports and trend analysis (the most used techniques by analysts).

### 3. References to the research

The references below are all published in JCR sports sciences (2 Q1, 1 Q2, 2 Q3) and psychology (1 Q1) peer review journals. Four have International squash collaborations and two involved GB Olympic or Paralympic coaches and performance analysts. These projects were supported by £50k funding for PhD fee and studentship from the English Institute of Sport.

1. Vučković, G., James, N., Hughes, M., Murray, S., Milanović, Z., Perš, J. & Sporiš, G. (2014). A New Method for Assessing Squash Tactics Using 15 Court Areas for Ball Locations. *Human Movement Science*, 34, 81-90. <https://doi.org/10.1016/j.humov.2014.01.002>.
2. Murray, S., James, N., Hughes, M.D., Perš, J., Mandeljc, R. & Vučković, G. (2016). Effects of rule changes on physical demands and shot characteristics of elite-standard men's squash and implications for training. *Journal of Sports Sciences*, 10, 2, 129-140. <https://doi.org/10.1080/02640414.2016.1216155>
3. Murray, S., James, N., Perš, J., Mandeljc, R. & Vučković, G. (2018). Using a situation awareness approach to determine decision-making behaviour in squash. *Journal of Sports Sciences*, 36, 12, 1415-1422. <https://doi.org/10.1080/02640414.2017.1389485>
4. Murray, S., James, N., Perš, J., Mandeljc, R. & Vučković, G. (2019). Using a Situation Awareness approach to identify differences in the performance profiles of the World's top two squash players and their opponents. *Frontiers in Psychology*, <https://doi.org/10.3389/fpsyg.2019.01036>
5. Nicholls, S., James, N., Bryant, E. & Wells, J. (2019). The implementation of performance analysis and feedback within Olympic sport.: The performance analyst's perspective. *International Journal of Sports Science and Coaching*, 14, 1, 63-71. <https://doi.org/10.1177%2F1747954118808081>
6. Nicholls, S., James, N., Bryant, E. & Wells, J. (2018). Elite coaches' use and engagement with performance analysis within Olympic and Paralympic sport. *International Journal of Performance Analysis in Sport*, 18, 5, 764-779. <https://doi.org/10.1080/24748668.2018.1517290>

### 4. Details of the impact

Impact has resulted from the introduction of performance analysis interventions that have changed behaviour in elite sport practice. It has been achieved through working in close collaboration with a number of elite sports organisations and players including England National squash squads and elite players, English Institute of Sport (EIS), UK Sport, High Performance Sport New Zealand (HPSNZ), and rugby (Ireland RFC), with research findings utilised by other GB Olympic and

Paralympic teams, through further advisory work with individual analysts and the delivery of specific workshops.

In relation to elite sport practice, impact has been particularly significant in squash where much of this work was pioneered, but has also been evident in other elite sports. The period of research and collaboration with the English National squash squads was one of unprecedented success for England squash. Three players (Laura Massaro, Nick Matthew and James Willstrop achieved world number one ranking between 2010-2016, including Laura Massaro in 2016 and Nick Matthew in 2014 - a feat that has not been achieved since - and individual Gold medals were won at the Commonwealth games by Nick Matthew (Glasgow 2014) and James Willstrop (Gold coast 2018).

Whilst the precise link between our research and performance is difficult to demonstrate, the testimonies of a number of senior sports scientists and coaches indicates the importance of this relationship. For example, the head of performance analysis at the EIS stated: *“the very high regard we have for Prof James and his team and... the impact their research has had on the practice of Great Britain Olympic teams [S1]”*. Likewise, the head of Sports Science at HPSNZ [S2] (previously England squash team manager and performance analyst) noted *“his (Prof James) work in this area is ground-breaking and considered world leading (in both the high performance and academic field). His interventions have resulted in improved training and feedback in many different sports, with clearly associated improved performance, as evidenced by an increased number of tournament successes and rises in World rankings”*

Three major areas of impact from this work have been evident: (1) the development of more accurate performance profiles of opponents and greater tactical planning; (2) the introduction of training adaptations; (3) improved communication between coaches and performance analysts.

### ***Development of more accurate performance profiles of opponents and greater tactical planning***

Development of the novel 15 court cell analysis system, initially through work with squash [R1], allowed the analysis of shot information in conjunction with movement information for the first time in squash. This enabled more accurate performance profiles of opponents to be created and was instrumental in England squash players receiving more pertinent information about their future opponents so that they could prepare for matches better. Our approach to research profiling of future opponent's playing styles has subsequently been applied to many other sports, specifically through our collaborations with football, rugby union, tennis and several GB Olympic and Paralympic sports. The impact of these collaborations is mainly seen through changes in practice, always with the goal of improved match performance.

The head of analytics and innovation for Ireland rugby [S5] commented that his practice has evolved as a consequence of our research. Specifically, *“our tactical planning involves the use of the methods presented in Prof James' research papers [R1, R2], we utilise his recommendations to present coherent game plans to the players. In my opinion our tactical planning and practices have improved because of these approaches resulting in better performances on the pitch”*

Analysis lead for the Lawn Tennis Association [S6] said *“Our relationship with Prof James and his research colleagues has provided us with new methods of opponent analysis [R1, R2], which have consistently provided insights that our coaches and players use to improve their tactical plans”*

Head of football analytics for Leicester City FC [S7] commented *“our goal of analysing data to provide better information for our coaches matches the research objectives of Professor James and his colleagues. We are a research led department and wish to place on record the high regard we have for the research produced at Middlesex University and the belief that our presentation of accurate and useful information to our club analysts for better profiling of opponents and performance trends has improved as a consequence of using these methods [R1, R2]”*.

### ***Introduction of training adaptations to improve performance***

Our research has led directly to a number of major adaptations in training. In squash, the analysis of changes in tactical shot selection as a consequence of rule changes [R2] led to changes in squash specific training. The coach of England squash stated “*the research [R2] showed how the games had changed because of the domination of Egypt. It was clear that we had to change our playing style [R3] to remain competitive. We did this by creating a shift in our National pathway and coaching philosophy ensuring that developing players are learning the more attacking, explosive style of play they will need to compete in the current elite landscape [S3]*”. Fitness sessions were altered to better reflect the changes in rally durations and the proportion of shots played to the front of the court. A new form of ‘ghosting’ (in response to [R2]) was introduced (this involves running typical squash trajectories, at elite level primarily for fitness conditioning, lower level players also develop better movement patterns) where the video of a player in competition was projected onto the front wall of the squash court. A player on court then mirrored the movement of the player on the video. This was used to condition players for the new patterns of play but also to prepare players for the demands of playing against a specific higher ranked player and opponents who displayed very different tactical approaches [R2]. The research on tactical shot selections [R4], to better understand the factors affecting decision-making, allowed coaches to better prepare players by identifying situations, and devising training sessions to improve performance, where anticipation was possible, defensive shots were tactically superior to more attacking ones, and vice versa, and what type of shots were to be expected from forthcoming opponents in different tactically important situations. A previous England coach [S4] and coach of 11 World titles said that “*this data highlighted to me that we needed to create more time pressure in the training environment with my players. As a result of this data I have now created a training environment that better replicates the demands of the modern game of squash providing less time to make decisions, more emphasis on attacking your opponent by taking the ball short and take the ball more on the volley to put opponents under more time pressure.... Without this research I feel I would not be creating the optimal learning environment for the world leading players*”

#### **Improved communication between coaches and performance analysts**

Our research into the impact of PA [R5, R6] highlighted how the relationship between coaches and analysts affected the performance analysis process and hence its efficacy. This research alerted coaches and analysts of the importance of communication between them, particularly during coach planning sessions. Our research identified over 30 aspects where improvements could be made. These were disseminated to all GB Olympic and Paralympic analysts for discussion on how to implement changes where necessary.

The head of performance analysis at the EIS [S1] stated “*We have also collaborated to better understand our working practices in relation to performance analysis and our interaction with the coaches. This work has been useful for our internal development plan but also published in International journals [R5, R6]*”

#### **5. Sources to corroborate the impact**

Letters of support from the following organisations, person’s role and context of their support

- S1. English Institute of Sport: Head of Performance Analysis, reporter.
- S2. High Performance Sport, New Zealand: Director of Innovation and Research (also Adjunct Professor of Sports Technology and Data Analytics at Auckland University of Technology; previously England squash team manager and Performance Analyst), reporter.
- S3. England Squash: England head coach, reporter.
- S4. England Squash: Ex England head coach, reporter.
- S5. Irish Rugby Union: Head of analytics and innovation, reporter.
- S6. Lawn Tennis Association: Analysis lead, reporter.
- S7. Leicester City FC: Head of football analytics, reporter.