Institution: University of Bath

Unit of Assessment: 26: Sport and Exercise Sciences, Leisure and Tourism

Title of case study: Improving Elite Sports Performance

1. Summary of the impact

This case study demonstrates how research at the University of Bath on athlete technique and performance in sprinting and hurdling events has been translated back to the end users in order to improve their performance. The primary pathway to impact is via Dr Salo's involvement in applied work with virtually all top British sprinters and hurdlers and their coaches over the last 5 years (including all those who have represented Britain in major Championships). As a consequence of his research since 1998, Dr Salo has helped specific athletes to win medals, brought new insights to coach education and practice, instigated changes to routine practices within UK Athletics and also translated his expertise to other Olympic sports.

2. Underpinning research

Background: Research on technique and consequent knowledge transfer by improving coaches and athletes' understanding of performance is one way to boost the chances of success in competition. Athletes are important role models and an increase in participation as a result of their success can be strongly linked to wider social and economic benefits. For example, athletics (the major sport researched in this case study) has seen a 25% surge in participation in England since the London 2012 Olympic Games (Sport England Active People Survey 7, June 2013). Further, when proudly revealing a 25% increase in profits the Chief Executive of a leading sports retailer, Sports Direct, stated: "*There is no doubt that Team GB's outstanding performance has helped increase the awareness and popularity of sport across the UK*" (Sports Direct International Plc. company statement, 13 December 2012).

Context of Research: Dr Salo has been employed by the University of Bath since 1998 (current position: Senior Lecturer). In line with our Integrative Human Performance research group focus, the main aim of his research is to understand the fundamental principles underlying performance in order to improve an individual athlete's technique and efficiency. He specialises in the technique of elite sprinters and hurdlers. Research on elite athletes is inherently difficult, as athletes and their coaches are generally hesitant to participate in research due to fear of making changes to their normal training.

Paper 1: This research in 2000-2001 carried out in Bath (supported by a grant from UK Athletics [7]) investigated relay exchanges utilising British national men's 4x100 m team as participants. The core of this squad comprised World Championship 4x100 m medallists. This research identified the best baton change-over distances in the exchange area, athletes' running velocity patterns and their interaction with each other.

Paper 2: This is the first paper in sprint hurdling that assessed the effect of fatigue and different running velocities (at different parts of the run) on hurdle clearances. The research was fully conducted in Bath in 2000-2004 and was partly supported by a Royal Society grant [6]. The participants included World Championship and Olympic athletes. This research found critical technique elements that appeared when fatigued and what happens to technique when the athletes do not reach the right take-off distance. Also, this paper demonstrated how changing running velocity alters the take-off distance and hurdle clearance path, which has not been considered in coach education previously.

Paper 3: This research was conducted in Bath in 2004-2006 when Ian Bezodis was a PhD student and Dr Salo was his lead supervisor (Prof. Kerwin, who was a co-supervisor, was also employed by the University of Bath until autumn 2005). The research was partly supported by Dr Salo's grants from UK Athletics [8-9, 11]. The mechanics of sprinting has been rarely examined with true elite athletes running at high velocities. Participants in this research included an Olympic relay gold medal winner whose 100 m personal best was under 10 seconds. Elite athletes are a very specific

group and it is difficult or impossible to predict their technique based on the performance of lower level athletes. This paper highlighted that the role of muscles around the knee joint in maximal velocity sprinting may be different to that previously believed to be the case.

Paper 4 (and presentation receiving award in 2009 [13]): This research, which was carried out in 2006-2009 and partly supported by grants from UK Athletics [9, 11], provided insight into the most important and appropriate measure of the sprint start and how the best starts are performed. This study proved that previous research had overlooked the correct performance measure in sprint starts. Without the right performance outcome, one cannot provide athletes and coaches with appropriate advice. Participants in this research included several athletes who had reached the finals either at the European or World Indoor Championships during the previous two years. This research was carried out in Bath when Neil Bezodis was a PhD student (Dr Salo was his lead supervisor and Dr Trewartha co-supervisor; Dr Trewartha has also been employed by the University of Bath over the whole time period of this research; currently as Senior Lecturer).

Paper 5: This is the first paper to longitudinally assess a group of world absolute top elite sprinters, most of whom ran under 10 seconds several times during the study period (partly supported by grants from UK Athletics [8-9,12] and Leverhulme Trust [10]). The literature contains many debates about whether step length (SL) or step frequency (SF) is the most critical factor in sprinting (based on average performances of groups). However, elite athletes need to 'fine tune' their own performance and this research found that some athletes were more SL reliant and some more SF reliant. This has implications for athlete preparation for competition. For example, SL-reliant athletes might need to focus more on force and flexibility whereas SF-reliant athletes might be better concentrating on nervous system considerations. All co-authors were in Bath when the main bulk of this research was conducted in 2003-2005. Dr Batterham carried out further statistical analysis after he had moved to the University of Teesside. An article based on this research received 'Honourable Mention' by the European Athletics Association [14].

3. References to the research

[1] Salo, A.I.T. (2001). Running velocities and baton change-overs in 4 x 100 m relay exchanges. In: Blackwell, J.R. (ed.) *Proceedings of Oral Sessions XIX International Symposium on Biomechanics in Sports.* University of San Francisco, USA. pp. 87-90. (URL: https://ojs.ub.uni-konstanz.de/cpa/article/view/3825/3544)

[2] Salo, A.I.T. and Scarborough, S. (2006). Changes in technique within a sprint hurdle run. *Sports Biomechanics*, 5 (2), 155-167. (DOI: 10.1080/14763140608522871)

[3] Bezodis, I., Kerwin, D.G. and Salo, A.I.T. (2008). Lower limb mechanics during the support phase of maximum velocity sprint running. *Medicine and Science in Sports and Exercise*, 40 (4), 707-715. (DOI: 10.1249/MSS.0b013e318162d162)

[4] Bezodis, N.E., Salo, A.I.T. and Trewartha, G. (2010). Choice of sprint start performance measure affects the performance-based ranking within a group of sprinters: which is the most appropriate measure? *Sports Biomechanics*, 9 (4), 258-269. (DOI: 10.1080/14763141.2010.538713)

[5] Salo, A.I.T., Bezodis, I.N., Batterham, A.M. and Kerwin, D.G. (2011). Elite sprinting: Are athletes individually step length or step frequency reliant? *Medicine and Science in Sports and Exercise*, 43(6), 1055-1062. (DOI: 10.1249/MSS.0b013e318201f6f8)

Grants (all to Dr Salo as sole researcher while he has worked at the University of Bath)

[6]	2000	£9,820	Royal Society (Equipment grant)
[7]	2000	£3,900	UK Athletics (Efficiency in relay exchange)
[8]	2001-05	£65,400	UK Athletics (Performance indicators in running)
[9]	2002-06	£60,000	UK Athletics (Critical aspects of sprinting)
[10]	2004-05	£21,000	Leverhulme Trust (Modelling of sprint start in Athletics)
[11]	2006-08	£57,600	UK Athletics (Effective sprinting)
[12]	2009-11	£80,000	UK Athletics (Improve velocity in sprinting)

Awards received

[13] 2009: Bezodis, N.E., Trewartha, G. and Salo, A.I.T. Development, evaluation and application of a simulation model of a sprinter during the first stance phase. 1st place: Hans Gros New Investigator Award, International Society of Biomechanics in Sports.

[14] 2010: Salo, A.I.T., Bezodis, I.N. and Kerwin, D.G. The individual step length-step frequency interaction patterns in elite sprinters. Honourable Mention. European Athletics Innovation Awards

4. Details of the impact

Pathway to Impact: The pathway to impact from this research is primarily via Dr Salo's broad and significant involvement in applied work with practitioners. Dr Salo's close working relationship with UK Athletics has allowed him to translate the acquired knowledge directly to the very highest level of the sport. While research on elite athletes is inherently difficult and changes are in most cases practically impossible to quantify at the athlete level due to so many extraneous variables, it can be clearly demonstrated that UK Athletics and British Bob Skeleton have changed their practices, and that both coaches and athletes appreciate and value the insights drawn from Dr Salo's work.

Using research to inform professional work and practice: The research from paper 1 improved understanding of key issues in 4x100 m relay exchanges and how to measure these baton exchanges. Based on this research, Dr Salo created a videotaping and analysis template that has been used by UK Athletics over the last 10 years. This work also prompted UK Athletics to adapt and develop a new approach which included inviting and supporting Dr Salo to attend pre-competition training camps and to be part of the support team at major Championships. During the current REF cycle, Dr Salo has analysed over 90% of all British national senior relay team activities (52 relay training sessions and 49 relay competitions). These include the following preparation camps and Championships: Beijing Olympics 2008, Berlin World Championships 2009, Barcelona European Championships 2010, Daegu World Championships 2011 and London Olympics 2012 [15]. Notably, Dr Salo was the only biomechanical technical personnel in the whole of Team GB for the Beijing Olympics in 2008 [16].

During these preparation camps and the Championships, Dr Salo worked with the best British athletes and their coaches – advising and supporting their preparations for better performances. Adding the aforementioned relay work (based on paper 1), he has also been able to translate the research knowledge from papers 2 (hurdling), 3 (sprinting) and 4 (sprint start) to advise athletes' technique in the training camp environment. Over 100 top British sprinters and hurdlers and their coaches have received analysis and feedback from Dr Salo in the last 5 years (i.e. all those who have represented Great Britain in major Championships). His work and input have been publicly appreciated by athletes including a quote from British World Championship medal sprinter Harry Aikines-Aryeetey in an article in The Washington Post in summer 2012: "*He films all our (baton) exchanges and then goes off to calculate how much faster we could go if we did things differently. Getting his feedback gives us confidence we're doing the right things and everything possible to win a medal*" [17]. Further, the UK Athletics Performance Director stated: "*He has made a valuable contribution to inform coaches and athletes on performances across all speed events with a very direct contribution, for example, towards British men's 4x100 m relay team winning a World Championships bronze medal in Berlin 2009*." [15]. Dr Salo's translational research and role as part of the UK Athletics support team is unique in British HEIs in relation to athletics.

Influence on professional training and enhance professional practice: Dr Salo has been invited to participate in off-the-track work as an invited speaker for UK Athletics workshops (during the current REF cycle in Novembers 2008, 2009, 2010 and 2011) providing education for athletes and top coaches about relay running (paper 1). Each workshop included up to 10 of the best male and female sprinters in the UK. The purpose of these workshops was to go through performances from the previous summer and to learn lessons for the future. While the target audience as top athletes is inevitably limited by the elite nature of the group, the same message reaches broader audiences via the coaches, as they coach wider groups of athletes (including youth). Further workshops have been held for hurdle coaches in November 2011 and December 2012 (15-20 coaches in each). Key topics in these presentations were the further insight into hurdling technique found in paper 2 (technique changes when fatigued and how take-off distances are related to

running velocity). These workshops were the first time that these issues had been introduced into formal coach education in the UK. The National Event coach for hurdles at UK Athletics (who has personally coached athletes to ten Olympic or World Championship Gold medals) has utilised this insight in his coaching over the last few years: "*I have worked with Dr Aki Salo on various sprint and hurdles related projects since 1998. All this time, he has been able to uniquely explain biomechanics and research issues with very applied and understandable way to help my coaching processes. For example, in the early 2000's, Dr Salo's work revealed how hurdle take-off distance is dependent on running velocity, which helped me to implement changes to my athletes' running technique. I am still using the same principles with my current athletes who include, for example, Lawrence Clark (4th at the London Olympics 2012 in 110 m hurdles) and Andrew Pozzi (4th at the 2012 World Indoor Championships in 60 m hurdles)*." [18]. Further, based on the research in paper 5, Dr Salo and UK Athletics have analysed critical step length and step frequency values from all 100 m finalists in the UK Championships since 2005 to inform coaches on their athletes' technique [15]. Consequently, this work has reached all 80 male and female finalists and their coaches in the current REF cycle.

Stimulated practitioner debate and wider dissemination: Dr Salo's work has also found wider national and international non-science audience – for example, paper 5 was specifically discussed in American coaching web-sites and blogs in spring 2011 [19]. His applied research work with UK Athletics (based on papers 1, 3, 4 & 5) has been featured in the Universities UK reports on "the Impact of Universities" and "The Impact of University Research and Sports Development" as well as in mass media including international news agencies, newspapers and national TV in 2012 [20]. This work also received governing body endorsement with an honourable mention from the European Athletics Association [14].

Influence on policy: Dr Salo's work at the Berlin World Championships in 2009 forced the International Association of Athletics Federations to clarify and modify their relay running rules (*the definition of the exact starting point of the baton exchange*) in the following autumn [15].

Changed practice and influence on professional standards: The impact and benefit of Dr Salo's research is not limited only to athletics sprinting. Based on research knowledge and findings on sprint start and sprinting (papers 3-5), UK Sport and British Bob Skeleton contracted the University of Bath to translate his expertise to the bob skeleton start in 2012-2014 [21]. This demonstrates that Dr Salo's research can be transferred to and have an impact across other sports and this project is the first of its kind for bob skeleton. The Head of Research and Innovation at UK Sport acknowledged: "*Bob Skeleton has recently been one of the most successful winter sports for Team GB. In order to keep ahead of our competitors, UK Sport and British Bob Skeleton decided to start a specific bob skeleton start project in 2011. Based on Dr Salo's research expertise in athletics sprint start and generally in sprinting, it made him a natural choice to lead this project and translate his knowledge to other sports which has not utilised applied sport science to its full potential*." [21].

5. Sources to corroborate the impact

[15] Testimonial from the Performance Director, UK Athletics
[16] Official Team GB Handbook - Beijing 2008 Olympic Games
[17] 4x100 m runners' BBC interview (22/08/2009) after winning a 4x100m bronze medal in World Championships, and an athlete's comments in Washington Post 20/6/2012.
[18] Testimonial from the National Event Coach for hurdles, UK Athletics
[19] American coaching web-site discussions and blogs:
http://www.elitetrack.com/forums/viewthread/9587
http://jcissik.wordpress.com/2011/06/10/over-reliance-on-stride-lengthfrequency-could-impact-sprinting-performance/
http://www.scienceofrunning.com/2010/11/speed-stride-length-x-stride-frequency.html
[20] e.g. Universities UK - Olympic and Paralympic Games: The Impact of Universities (30/4/12), Universities UK - Olympic and Paralympic Games: The Impact of University Research and Sport Development (2/5/12) Channel 4 documentary 'BEN' (18/8/12), Associate Press interview published worldwide (20/6/12), interview in New York Times (23/7/12)
[21] Testimonial from the Head of Research & Innovation, UK Sport