Institution: Swansea University
Unit of Assessment: 26 - Sports and Exercise Sciences, Leisure and Tourism
Title of case study: Pre-competition strategies for enhanced performance in elite athletes
1. Summary of the impact

Research conducted at Swansea University has helped transform the pre-competition strategies of elite sport. This research has focused mainly on the application of post-activation potentiation (PAP), manipulation of warm-up variables and morning priming for enhanced performance. This work has had significant impact on the recent successes of elite skeleton bobsleigh athletes at the 2010 Winter Olympics (e.g. ~4% improvement on their key performance indicator) and a number of other British sports during London 2012 (e.g. British Cycling who won 12 medals). The research continues to impact elite sports and is being embedded into athletes' pre-competition routines for Sochi 2014 and Rio 2016.

2. Underpinning research

The key research that underpins this impact case study has been developed at Swansea University in collaboration with UK Sport over the last 8 years. This research has explored three key areas of athlete pre-competition preparation; 1) practical application of PAP, 2) warm-up manipulation, and 3) the effect of morning exercise on subsequent performance. The ability to produce high levels of muscular power is considered an essential component of success in many sports (e.g. sprint cycling, skeleton and bobsleigh, rugby) and a number of pre-competition routines can be manipulated in the hours leading up to competition to ensure athletes are optimally prepared for competition.

Current research has produced conflicting results on athletes' ability to harness PAP. This conflict has been explained by the lack of agreement between studies on optimal recovery time required between the preload stimulus and the subsequent sporting activity with studies reporting recovery periods ranging from 0 to 18.5 minutes. The focus of this research was to determine how best to apply PAP to the current preparation routines of elite sportspeople to improve their performance. Our research concluded that on average 8 minutes recovery was required between the preload stimulus and subsequent performance to optimise the benefits of PAP (R1). This research has been replicated within our group and expanded to show that PAP can be harnessed to improve sprinting performance (R2). The references detailed above have formed the foundations for the incorporation of PAP into pre-competition routines in a number of elite winter and summer Olympic sports.

The second series of our studies (R2-R5) have reported two strategies to attenuate the reported decline in body temperature following the completion of the athlete's warm-up. A number of sports have significant periods of time that athletes must wait between the completion of their warm-up and start of competition, during this period the athletes muscle temperature rapidly drops, losing a large proportion of the physiological benefits that go with increases muscle temperature. Our research has shown that completing the warm-up as close as practically possible (within the constraints of the sports regulations, e.g., swimmers must enter a marshalling call room 20 minutes prior to racing) to the start of the competition helps maintain body temperature and this maintenance leads to improvements in performance (R3, R4). Secondly research conducted at Swansea has demonstrated that getting athletes to wear passive heat maintenance garments in

the period between the completion of their warm-up and the subsequent performance leads again to better temperature maintenance and hence greater improvements in performance (R3, R5).

The final study (R6) demonstrated that a bout of morning exercise managed to attenuate the normal circadian decline in the key anabolic hormone and this led to a significant improvement in afternoon performance.

The research outlined above was conducted in elite sporting populations in conjunction with UK Sport and has led to publications in journals that are leading in their respective fields. In addition the work has been conducted with our key beneficiary organisations to ensure it has direct impact of its intended end users (e.g. elite sport). For example, combining all the above mentioned strategies lead to a ~4% improvement in elite skeleton bobsleigh athletes' key performance indicator (R3) and was incorporated into their winter Olympic pre-competition routine. During the 2012 winter Olympics they won Great Britain's first Gold Medal in an individual event for 30 years, and the first by a woman for 58 years.

This research was undertaken by Dr. Liam Kilduff (Associate Professor, A-STEM, Swansea University); all the above-mentioned work has been carried out while Dr Kilduff has been employed by Swansea University (2002 – Present).

3. References to the research

The following are published in ISI-listed international journals, and are leading journals in the particular fields of research they represent:

R1. **L.P. Kilduff**, N. Owen, H. Bevan, M. Bennett, M.I.C. Kingsley, D. Cunningham. (2008). Influence of Recovery time on Postactivation Potentiation in Professional Rugby Players. *J. Sports Science, 26: 795-802.*

R2. Bevan, H., N. Owen, D. Cunningham, E. Tooley, **L.P. Kilduff**. (2010). Influence of Postactivation Potentiation on sprinting performance in Professional Rugby Players. *J. Strength & Conditioning Res*. 24:701-5.

R3. Cook, C.J., Holdcroft, D., Drawer, S. **Kilduff, L.P.** (2013). Designing a warm-up protocol for elite bob-skeleton athletes. *International J. Sports Physiology & Performance, 8:* 213-215.

R4. West, D.J., Cunningham, D.J., Bracken, R., Dietzig, B., Crewther, B.T., Cook, C.J. **Kilduff, L.P.** (2013). Influence of post-warm-up recovery time on swim performance in international swimmers. *J. Science & Medicine in Sport, 16: 172-176.*

R5. **Kilduff, L.**P., West, D.J., Williams, N., C.J. Cook. (2013). The influence of passive heat maintenance on lower body power and repeated sprint ability in professional rugby players. *J. Science & Medicine in Sport, 16: 482-486.*

R6. Cook CJ, **Kilduff LP**, Crewther BT, Beaven M, West DJ. (In Press) Morning based strength training improves afternoon physical performance in rugby union players. *J. Science & Medicine in Sport. (*doi: pii: S1440-2440(13)00103-5. 10.1016/j.jsams.2013.04.016).

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Grant Title: Science, Medicine and Technology Innovation for High performance sport (Phase 1) (*Principal Investigator: Dr Liam Kilduff*). Collaborative Partners: Sport Wales. A4B Funding (Welsh Government HE09KEP1014). £57,582. 01/07/2012 – 31/03/2013.

Grant Title: Application of a solid-state saliva-based biosensor system to monitor physiological stress in elite athletes. (*Principal Investigator: Dr Liam Kilduff*). Collaborative Partners: UK Sport. ESPRIT through Engineering and Physical Science Research Council (EPH0009744/1). £148,769. 01/04/2010 – 30/09/2011.

4. Details of the impact

Our research is concerned with identifying optimal pre-competition strategies that can be exploited for performance gain by elite sportspeople. In the context of elite sport, the smallest of margins can often make the difference between winning and losing. Swansea University researchers, led by Dr. Kilduff in collaboration with UK Sport, have generated the key research findings underpinning this work. More specifically these findings provided the basis for current preparation strategies for a number of top European professional rugby teams (e.g. Scarlets & Biarritz Rugby), elite winter (e.g. British Bobsleigh and Skelton Bobsleigh) and summer Olympic sports (e.g. British Cycling Team) and contributed to their recent successes at Vancouver Winter and London Summer Olympic games. Practitioners who work in the area of applied sports physiology and strength & conditioning have also benefitted significantly from this work by applying these findings into their pre-competition strategies – quotes cited below will bear testament to this. Furthermore, due to the involvement of UK Sport in all of this work, it was received by a significantly wider elite sport audience in the years leading into the London 2012 and is now also being incorporated into Winter Sports leading into Sochi 2014 and Rio 2016.

The work on the application of PAP and warm-up carried out at Swansea University has changed the pre-competition routines of a large number of key sporting organisations that compete at the highest level of sport. In summary, this work has directly impacted and now become embedded in the pre-competition preparation routines of British Bobsleigh, British Skeleton Bobsleigh, British Cycling, Welsh Swimming, Scarlets Rugby, Biarritz Rugby Teams.

Director of Marginal Gains, British Cycling:

"*This letter is in support of the impact Dr. Kilduff sports science research has had on our preparation strategies within British Cycling. Dr. Kilduff's research around the application of Postactivation Potentiation (PAP) to elite athletes and in particular determining the optimal time between the PAP stimulus and the subsequent performance has allowed the "Marginal Gains Team" to gain a greater understanding of the role PAP plays in improving starts in elite cycling and has made a contribution to subsequent improvements in cycling performance. We now incorporate PAP into a number of our athletes pre- competition warm-ups. In addition to PAP his work with Dr Christian Cook (UK Sport) on maintaining body temperature between the completion of the warm-up and subsequent race has allowed GB cyclists to minimize the problem of heat loss within their warm-up routines resulting in further marginal gains in elite performance. These marginal gains are*

key to continued success in international cycling competition. Dr Kilduff's research has had important significance and impact on our current practice at British Cycling".

Lead Sport Science, Great Britain Bobsleigh

"*Dr Kilduff's research on Postactivation Potentiation (PAP), passive heat maintenance and morning priming has allowed us to dramatically change our preparation routines which we feel has had a positive impact on our performance over last season and we will be continuing with these routines into Sochi 2014. In the 2012/13 season GB World Cup crews made improvements on 50m start time in a range from 0.04 seconds (women) to up to 0.12 seconds (men). This had a dramatic impact on overall performance and end ranking. We will be continuing in this line of research and development to find as much physical advantage in the push start as we can. The primary research was a highly significant step towards a performance shift. Some of the secondary research planned around new findings and results of implementation ... also holds exciting prospects. Dr Kilduff's research has important significance and impact of our current practice at British Bobsleigh and we feel this will be a very important part of our preparations in Sochi 2014.*"

Furthermore, our work around passive heat maintenance has also impacted key winter and summer Olympic sports:

Director of Research and Innovation, UK Sport stated:

"*The impact you have delivered on the wider area of warm up, potentiation and 'competitive readiness' in elite athletes has directly impacted on applied practice and performance with particular emphasis on GB's winter sport programmes. Part of the research work carried out in this group in preparation for Vancouver 2010 has recently been published in the International Journal of Sports Physiology and Performance (Designing a warm-up protocol for elite bob-skeleton athletes).*"

In a press release the Director of Research and Innovation for UK Sport also wrote (following the successful performance of one of the female skeleton athletes at the Vancouver games)

"*Dr. Kilduff and his team have supported us specifically in aiding the skeleton athletes' physical performance. Dr. Kilduff and his team worked closely with members of British Skeleton and the English Institute for Sport, on a number of strategies looking that optimized their preparation strategies*".

5. Sources to corroborate the impact

Letters of support can be provided from the following organisation to corroborate this case study:

1. Head of Research and Innovation, UK Sport
2. Director of Marginal Gains, British Cycling
3. Head of Sport Science, British Skeleton Bobsleigh
4. Lead Sport Scientist, Great Britain Bobsleigh
5. Head of Physical Performance, Scarlets Rugby
6. Head of Physical Performance, Biarritz Rugby
7. Head of Sports Science, Welsh Amateur Swimming Association
8. High Performance Manager, Sport Wales
9. Head of Strength & Conditioning, English Cricket Board