Institution: University of Exeter

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

a. Context. Exeter Sport and Health Science (SHS) researchers in both the Bioenergetics and Human Performance (BHP) and the Physical Activity and Health Across the Lifespan (PAHAL) groups work at the interface with a variety of partners in industry, the public and armed services, and national and international organisations to impact on commercial and economic interests, practitioner and professional practice and public policy. Through the modification of physiological, nutritional, biomechanical and psychological factors, and systematic synthesis, our research is targeted at enhancing human health and performance. Our three Case Studies provide details of how we have maximised impact, but the following selected examples provide a broader context.

Impact on commercial partners: In addition to our work on dietary nitrate supplementation (Case Study 1), staff have worked closely with companies such as GlaxoSmithKline, Kelloggs (Williams), Altitude Centre, Cherry Marketing Institute, and CherryActive Ltd (Bowtell) to identify the benefits of other ergogenic aids among paediatric and adult populations. Work with NIKE and Umbro (Dixon & Stiles) has shown how performance and injury are influenced by different footwear and surfaces, and this has impacted on the development of new footwear and sport surface products. Work by Wilson and Vine on optimizing human performance at the interface with technology (using eye tracking systems) has led to changes in Flybe's pilot simulation training, and surgical training with 'Intuitive Surgical's' *da Vinci*® System, to account for the effects of stress on attentional processes.

Impact on armed services: Since 2000, work by Dixon with the Institute of Naval Medicine (INM) has focused on reducing injuries among Royal Marine (RM) recruits which cost the MoD an estimated £8m per year due to loss in training time. The research has examined the use of footwear manipulations to reduce injury risk, and identified biomechanical risk factors for injury leading to the development of both a customised insole and a biomechanical screening database. From experimental work on loading at the plantar foot surface, a specific insole was identified and tested with RM recruits. An INM report documented a significant reduction in overuse injury with the use of these cushioning insoles. Further research identified that of the standard issue footwear types for Royal Marines - the combat assault boot and the gym trainer - there was significantly greater loading at the forefoot and torque about the ankle for the boot condition compared with the trainer, leading to a recommendation to maximise the use of the trainer during recruit training (where practical).

Impact on sport-related organisations: In addition to our applied physiology research (Case Study 2), psychologists (Rees, Vine, Wilson), physiologists (Barker, Gracia-Marco, Jones, Williams,) and biomechanists (Dixon, Stiles) have worked closely with many organisations to apply their research to optimize individual and team performance at international (e.g., IOC, FIFA, International Tennis Federation, Fédération Internationale de Gymnastique, IAAF), national (e.g., UK Sport, Rugby Football Union (RFU), English Football Association, Lawn Tennis Association, England Athletics, British Cycling, England and Wales Cricket Board (ECB), British Gymnastics Association, Italian Olympic Committee) and regional level (e.g., 'quiet eye' golf coach training).

Impact on public services: In addition to our work on physical activity, mental health and nicotine addiction (Case Study 3), Rees and Hillsdon have established robust evaluation procedures, using a stepped wedge design, with Active Devon to determine the effectiveness of a rural initiative to promote physical activity. Wilson and Vine have influenced the way surgeons are trained in the South West by John McGrath (Urologist Specialist Registrar, Royal Devon & Exeter NHS Trust) and colleagues, based on their research on eye movement and gaze training to enhance laparoscopic technical skill acquisition and multi-tasking performance.

Impact on government and international policy-making organisations: In addition to Case Study 3, Hillsdon gave oral expert evidence in 2011 to a House of Lords Science and Technology Select Committee on (Health) Behaviour Change, as a means of achieving government policy goals. Since 2012, Hillsdon has been a member of the National Institute for Health and Care Excellence (NICE) core Public Health Advisory Committee (PHAC), responsible for the development of public health guidance. Topics are identified by the Department of Health and the PHAC considers the evidence and makes recommendations for people working in the NHS, local government and in the wider public, private and voluntary sectors. In 2012, based on his work on national health surveys, environment and health inequalities, Hillsdon was one of 10 European-wide technical experts invited to develop World Health Organisation (WHO) guidance on physical activity promotion for socially disadvantaged groups, focusing on the role of healthy environments.

b. Approach to impact

Our sustained focus on research impact throughout the REF period can be demonstrated through a number of approaches, including: (i) strengthening areas with potential impact; (ii) capacity building through strategic partnerships; and (iii) providing infrastructure, support and training to build capacity to impact on human performance and health. Wherever possible, potential beneficiaries are involved throughout the research process (from design to dissemination).

i) *Strengthening research areas with potential impact.*

Since 2008 we have increased our capacity to maximise impact related to human performance and health through the appointment of new researchers. Physiologists Krustrup (Professor), Mohr (Senior Research Fellow), Bowtell (Assoc Prof), Vanhatalo, Bailey and Jackman (Lecturers) have all added to the range of partnerships across different sectors mentioned above. Vine (Lecturer) has greatly enhanced capacity in visuo-attentional research, led by Wilson, focused on improving sport and human performance in various tasks (e.g., the training of pilots and surgeons, elite shooters and golfers). Stiles (Lecturer, and now Senior Lecturer, SL) added biomechanics expertise to further develop work with sports equipment businesses and organisations, especially in connection with bone loading (with an Innovation Award from the National Osteoporosis Society). http://www.nos.org.uk/page.aspx?pid=1221).

Applied health research capacity was strengthened by appointing Hillsdon (Assoc Prof) with experience of health service research (e.g., primary care trials), and Krustrup with trans-European experience of team sports and health among the homeless; patients with hypertension, diabetes, and cancer; and obese children. SHS was involved in the inception of the University's Translational Medicine Science Strategy research theme in 2008, and this has led to capacity building in partnership with the University of Exeter Medical School (UEMS), Biosciences and Psychology. Barker and Gracia-Marco (Lecturers), and Metcalf (SL) added capacity to the Children's Health and Exercise Research Centre for working with clinical populations (e.g., with cystic fibrosis, poor bone health).

ii) Capacity building through strategic partnerships with end users.

To ensure we asked the right research questions we developed a number of strategic partnerships with end users. In the REF period, staff working in the BHP group have been awarded £1.64m from industrial partners such as Unilever (£66k for accelerometer development), International Tennis Federation and Umbro (£30k for surfaces and injury), GlaxoSmithKline, Kelloggs, and Gatorade/PepsiCo (>£600k, with a further $1.1m just awarded), and sports governing bodies, such as the ECB (£81k from a ESRC Case Studentship for understanding junior transitions into the ECB Performance Pathway), Rugby Football Union (£20k for adapting rugby for juniors), MoD (£6k for injury prevention), Lawn Tennis Association (designing hypoxic training protocols), UK Sport (£100k for understanding career development and transitions among Olympians), and FIFA (£83k for studies investigating football for health in women).

We strategically developed and maintained links with various local and national health-related agencies such as Devon County Council (£12k for work on evaluating rural physical activity promotion), and the Royal Devon and Exeter Healthcare Trust (£20k for exercise testing with young cystic fibrosis patients). While conducting internationally important trials (e.g., HEALTH; TREAD; EARS; GETuP), we have received over £150k of local NHS service support costs to test the acceptability and effectiveness of interventions among NHS patients. Case Study 3 provides more detail on how service users and providers engaged in all stages of the research.

iii) *Providing infrastructure, support and training to support impact.*

To deliver our strategy to increase impact capacity we have utilised several approaches, including use of the University's Research & Knowledge Transfer (RKT) support, and adding assessment of impact activities into our Performance and Development Review (PDR) annual review process for staff. Members of RKT have facilitated the development of many of the partnerships with businesses, organisations and agencies (see above). They have also provided business vouchers, and contract negotiation expertise. As an example, the 'Link Fund' was used to support Vine to visit the USA to foster research links with Intuitive Surgical which led to funding of $349k to assess the motor control and psychological benefits of robotically assisted surgery. Within the College of Life and Environmental Science (CLES), a Business Liaison Officer (Denbigh) helps staff to develop partnerships. For example, Vine and Lavric (Psychology), with co-investigators in Arizona, Amsterdam, Birmingham, received a £10k HEFCE Open Innovation Fund grant to work with Flybe, which led to a £191k in-kind contribution as part of an ESRC bid.

An ESRC Cluster capacity-building initiative in Sport, Leisure and Tourism was awarded in 2008 to the Business School with SHS staff on the management board. The purpose of this Centre is to help business and organisations from the private, public and voluntary sectors across the UK with research or training needs. Business vouchers have been awarded to facilitate collaborations, and 4 PhD Case Studentships were awarded, involving matched support from the SW Regional Legacy in Arts and Youth Sports (RELAYS), the RFU, ECB and Active Devon.

The University Press Office actively disseminates information from published scientific papers. For example, since 2009, research on dietary nitrate (beetroot juice) supplementation on exercise performance, described in one of our Case Studies, has led to interviews in documentaries aired on BBC1, BBC2, C4, Radio 4, and Radio 5 and across a wide range of global media.

c. Strategy and plans

Our strategy for maintaining and developing a culture that places great importance on impact will continue to involve a requirement for all staff to articulate their approaches in their annual PDR, as it has done since 2009. Staff are encouraged to compete in the University's annual Impact Awards competition in November, and have the support of a CLES Business Liaison Officer, as well as RKT to work with partner organisations.

Staff in both our research groups, BHP and PAHAL, individually and collectively identify potential partners and ways to increase impact within their annual Personal Development Plans. Within the BHP group, in addition to existing partnerships, we expect that relationships with GSK, Gatorade/PepsiCo, CherryActive and others concerned with the effects of ergogenic aids will become a major thrust. Commercial funding will continue to be sought, alongside RCUK and Charity funds. Strong progress has been made involving Wilson and Vine's work and we expect further partnerships to emerge associated with ExSELL (http://sshs.exeter.ac.uk/exsell/). Krustrup and Mohr have brought a new dimension to SHS biochemistry and metabolic research and we expect this to complement related work and provide new areas for growth in both performance and health related research. While some of the initial work on bioenergetics of supplements (e.g., nitrate and polyphenols) has been targeted at enhancing sport performance, we expect to fully explore the possibilities for enhancing human health (e.g., among special populations with impaired function). Within the PAHAL group, the aim is to continue to develop partnerships with colleagues in the UEMS and Psychology to gain funding for further trials on the effectiveness of physical activity interventions, and for the development of new technologies for assessing physical activity remotely and efficiently analysing data.

d. Relationship to case studies

The three case studies submitted reflect the range and level of impact our research is having, and how we ensure this occurs. These examples were selected to reflect our work in exercise and sport nutrition, sports performance, and physical activity and public health.

Case Study 1: Dietary nitrate supplementation. This work has been led by Jones since 2008, with significant contributions from Vanhatalo, Bailey and UEMS colleagues. With support from RKT, strategic international relationships with the sports nutrition industry have been developed, leading to > £600k funding (with a further $1.1m awarded in Oct 2013) to develop rigorous evidence for the effects of nitrate supplements on human health and performance.

Case Study 2: Applied exercise physiology. Jones has impacted on the ways in which sport scientists operate, coaches are trained, and athletes are prepared for competition. His original research on the physiological determinants of endurance exercise performance has altered practice in exercise testing procedures, training prescription and other interventions to enhance performance, with work being disseminated through regional, national and international workshops, guidelines, and books. This activity has been achieved through working closely with organisations such as UK Athletics and the English Institute of Sport to identify practitioner, and athlete, needs.

Case Study 3: Physical activity, mental health and nicotine addiction. Prolonged engagement by Taylor and colleagues with NHS policy makers (e.g., NICE), and global organisations producing evidence synthesis (e.g., Cochrane Systematic Reviews), Patient and Public Involvement groups, health care practitioners, and NIHR (Health Technology Assessment) prioritisation and review panels has helped to identify and address research questions with significant implications for UK health and well-being. This Case Study provides examples of this engagement in developing and conducting original rigorous research, disseminating findings back to those groups, and formulating guidelines for service provision nationally and internationally.