

<b>Institution: Bangor University (10007857)</b>
<b>Unit of Assessment: 24 Sport and Exercise Sciences, Leisure and Tourism</b>
<p><b>1. Unit context and structure, research and impact strategy</b></p> <p><b>Context and strategic aims of REF period</b></p> <p>In REF2014, the School of Sport, Health and Exercise Sciences (SSHES) and the School of Sport at Cardiff Metropolitan University (CMU) entered a combined submission under the auspices of the joint Institute for Research Excellence in Sport and Exercise (IRESE). That submission was a formal recognition of 20 years of research collaboration between the two schools. While collaboration has continued to thrive (see below), we prefer this time to submit Bangor and SSHES's research and impact contribution in its own right, as part of REF2021. This decision is grounded in the changing research and funding environment, natural staff turnover, and a refocused strategy for research and impact. Coordinated planning of research, investment, and activity, as well as careful succession planning in terms of group leadership and administrative roles, has allowed us to sustain and substantially expand our research contribution by increasing outputs and grant capture, the number of PhD student completions, and enhancing our engagement with external partners to produce impactful research.</p> <p><b>SSHES structures and achievements</b></p> <p>Research and impact activity within SSHES during the REF period has been shaped by its three constituent research groups – each steered by a senior academic. <b>(All funding figures quoted throughout reflect funded award values to Bangor unless explicitly stated as spend.)</b></p> <ul style="list-style-type: none"> <li>• The Institute for the Psychology of Elite Performance (IPEP; <b>Woodman</b>) has been concerned with developing and applying psychological principles to high-demand contexts of sports, military and business. To this end, IPEP has focused on the interactions between individuals and situations using psychometric and psychophysiological perspectives to generate high-quality multi-perspective data to inform researchers and external partners. IPEP has been successful in capturing research grants (worth GBP1,270,000 over this REF period) across a variety of funders including the Ministry of Defence (e.g., RAF Cranwell pilot training) and national sport organisations (e.g., England and Wales Cricket Board, Manchester City FC, Mountain training UK, Rugby Football Union, UK Sport). IPEP's programmes of individualised interdisciplinary resilience training that were used with the Lions and then England Men's International Cricket Teams in preparation for their winning 2019 World Cup campaign are particularly noteworthy.</li> <li>• The Extremes Research Group (ERG; <b>Walsh</b>, now <b>Oliver</b>) prioritises the multi-disciplinary understanding of human performance and health in extreme environments. This group has led on considerable grant capture from the Ministry of Defence (GBP1,315,000) as well as with other external agencies (Defence Science and Technology Laboratory, GBP296,000 European Hydration Institute, GBP275,000). The ERG has co-authored recent international consensus statements on nutrition and exercise (for the International Olympic Committee) and altitude illness. Underpinning such activity, ERG members have been integral to three international research expeditions (MEDEX 2015, <b>Macdonald, Oliver</b>; Global REACH 2016, <b>Moore</b>; Global REACH 2018, <b>Moore, Oliver</b>), enabling international multidisciplinary research teams to complete research at the highest altitude laboratories in the world. Illustrating further impact, the group's hot bath acclimatisation strategy has been adopted by several elite sports, including Sport Wales athletes for the 2018 Commonwealth Games.</li> <li>• The Physical Activity for Health and Well Being Centre (PAWB; <b>Lemmey</b>, now <b>Kubis</b>) has been concerned with exercise and nutrition factors in physical health and mental wellbeing across the lifespan. Their research is now housed in a newly refurbished Centre following a University investment of GBP1,033,000 to support the School's ambitions and build on PAWB's capacity in exercise prescription for chronic disease. Examples include the</li> </ul>

generation of exercise guidelines and resources for Rheumatology (produced for the American College of Sports Medicine) and for Nephrology (produced for the Renal Association) that have been implemented worldwide. Further strong collaborations involve other schools in the College of Human Sciences (e.g. the Schools of Psychology and Health Sciences) and HEIs (e.g., Liverpool University, Kings College London).

These three research groups have produced year-on-year increases in citation counts. Since REF2014: staff outputs have been cited in the literature more than 45,000 times (Google Scholar) and we have increased our combined research spend by 95% from GBP1,767,710 to GBP3,438,688. This includes GBP1,925,078 from industry sources for applied research and knowledge-exchange activities. PhD completions have more than doubled (26 to 56) and our contribution to the leadership of the discipline (in journal editorial positions) and invited conference presentations has increased by 67% (6 to 10 staff) and from 2 to 10 staff, respectively.

Continued collaboration with CMU and other partners has fostered expanded pan-Wales research across sports sciences institutes and offered leadership opportunities. Bangor leads the ESRC Doctoral Training Pathway (with CMU and Swansea University) in the social science of sports and exercise; one of only two training programmes in the UK. As part of this, we have established a pan-Wales annual PGR conference open to both ESRC and non-ESRC-funded doctoral students, attracting over 200 PGRs across institutions. To date, the pathway has awarded 13 studentships with Bangor and CMU securing 10 of these (five each). We have collaborated with CMU staff effectively on another six externally funded projects, influencing the practice of national and international sports organisations (e.g., UK Sport, British Triathlon). Indeed, with nine cross-institutional PhD student supervisions, this collaborative arrangement has now expanded beyond the psychology discipline into physiology, yielding 20 co-authored publications. CMU are also a partner in one of our impact case studies.

SSHES' and CMU's shared commitment to a joint funding and supervision PhD model has resulted in the production of several strong research projects and papers (e.g., **Moore's** high altitude physiology Global REACH expedition involving researchers from three continents). A third joint PhD studentship has been funded by Bangor to extend this effective collaboration into the next REF cycle. Bangor also co-founded (along with Sport Wales, Swansea University, and the University of South Wales) the Welsh Institute for Performance Science using funding from Welsh Government. Through the Welsh Institute for Performance Science, **Beattie, Blanchfield, Gottwald, Oliver** work with CMU and other Welsh academics to support Sport Wales in their preparation of Commonwealth Games teams and the development of industry-led research. Another pan-Wales collaboration is the recently established Welsh Institute of Physical Activity, Health and Sport, involving **Macdonald** and CMU staff, again coordinated by Sport Wales and funded by the Welsh Government. Welsh Institute of Physical Activity, Health and Sport brings together Welsh academics to inform and influence government policy to enhance physical activity and the health of the Welsh population.

Finally, the two impact case studies in this REF submission illustrate the contribution made by SSHES outside academia and describe resultant benefits to practice in elite sport and military organisations. Both are based on productive relationships with external partners, fostered over extended periods of time enabling the development of mutual respect and trust. Since our projects continue to meet the needs of our partners, our research activity attracts sustained funding. The first case study is based on UK Sport-funded research begun in 2009 by **Hardy L** that has changed and improved talent identification and development in elite cricket, rugby, and athletics. The second impact case study is based on a series of dietary investigations, funded by the Ministry of Defence and led by **Walsh and Oliver**, that have mitigated the negative effects of nutritional deficits on soldier body composition, immune health, and physical performance.

#### **Future strategic aims**

SSHES will continue to play a key role in the development of sports science across Wales, innovating and producing high-quality research across the disciplines. The School will build on

its research strengths: mental resilience; risk-taking; elite performance and talent development; human performance and health in extreme environments; dietary behaviour and metabolism; and exercise and vascular health. We will build on strong and well-established links with the Ministry of Defence, UK Sport, the English Institute of Sport, the England and Wales Cricket Board, Sport Wales, and the NHS. However, the School's **objective** is now **to extend the scale and reach of its research**. To achieve this, SSHES staff have co-produced a strategy with four elements: (a) to support a culture that values interdisciplinary collaboration and enables world-leading research, innovation, and enterprise to flourish; (b) to develop and maximise our research talent as the next generation of "world leaders", promoting rigorous science challenges the status quo; (c) to increase visibility and impact of our research beyond academia by fostering partnerships with business and enterprise, and; (d) to continue to support a vibrant and cohesive postgraduate research body valuing their contribution.

To implement this **strategy**, the *Institute for the Psychology of Elite Performance* will continue under new leadership (**Cooke**, mentored by **Woodman**). However, we plan to consolidate our physiology researchers from the *Extremes Research Group* and *Physical Activity for Health and Well Being (PAWB) Centre* into a single group, as the *Institute for Applied Human Physiology*, to be led by **Oliver** (and mentored by Professor Downing; Associate Pro-VC). This consolidation will expand research mentorship, facilitate multi-disciplinary collaboration across the SSHES and college, and will clarify our areas of expertise to external partners.

So, we will build on the following practices:

1. **Strategic appointments.** Careful recruitment will increase capacity in areas of strategic importance and facilitate intra- and inter-research group projects, and collaborations with other universities. To take one example, **Gallichio** (appointed 2020) has enhanced our capabilities in psychophysiology and applied cognitive neuroscience, allowing us to link up with other researchers in the schools of Health Sciences and Psychology to answer key questions in sporting and health domains.

2. **Strengthening cross-institution partnerships.** We have funded twelve research visits to world-leading laboratories (e.g., the Australian Institute for Sport; Ainslie's lab in the University of British Columbia, Canada; Gucciardi's lab in Curtin University, Australia; Masters' lab in Waikato University, New Zealand) during this REF period and are committed to supporting this activity during the next cycle. Given the success of our joint PhD studentships with CMU, we will expand our joint supervision model and engage other universities to enable the exchange of cutting-edge methodologies that can be shared across the School's research groups.

3. **Promotion of impact, innovation, and engagement.** We maintain an innovation budget of GBP25,000 to support SSHES staff (and postgraduate researchers) to develop their impact and engagement activities. We have and will prioritise further post-acceptance activities to better publicise outputs and make findings from our papers available to relevant stakeholders (e.g., using layperson summaries, infographics, and executive briefings).

4. **Expanded knowledge-exchange activities to develop commercial and industry partnerships.** We have been very successful in securing funding that incorporates bespoke training opportunities (e.g., entrepreneurial skills) and covering associated training costs. Most of this external funding has been for collaborative knowledge-exchange PGR projects with industry via the EU social fund. Our next step is to develop impactful post-Brexit industrial partnerships. To this end, the School is contributing to the university's programme, with Betsi Cadwaladr University Health Board (BCUHB), to develop a new North Wales Medical and Health Sciences School. We also contribute to the current C21 North Wales Medicine degree by supervising projects for Student Selected Components. Moreover, the new *Institute for Applied Human Physiology* will drive impactful collaboration with other schools in the college, linking in with the Bangor Institute for Health and Medical Research (BIHMR) and the UKCRC-registered clinical trials unit, NWORD. These partnerships will forge ever closer research and training links with the NHS and clinical partners and extend our interdisciplinary reach, for example, the recently

awarded ESRC DTP studentship with Manchester City FC incorporating health economics through Bangor University's Schools of Health and Medical Sciences).

### **Underpinning philosophical approach to research and impact excellence**

Two important outward-facing principles - collaboration/partnership and communication/dissemination – underscore our research impacts.

### **Collaboration, partnership and dissemination**

Funders now encourage researchers to consider impact in the formulation of projects and not just at the dissemination stage. This means involving research users in the development of the research questions and decisions about the most appropriate research methods. Our enduring partnerships with the English Cricket Board (ECB), UK Sport, the Ministry of Defence demonstrate that we already follow this practice. Our research developed the *model of equal expertise* concept (Hardy L & Parfitt, 1994) that has shaped how applied sport psychology practitioners engage with their clients. This is now the reality of our approach, enabling us to gain a thorough understanding of outside parties' requirements, how best to fulfil them, and how to leave a legacy within the organisation after the research project has been completed. Our effectiveness at fostering strong collaborative relationships is illustrated by successful income capture over extended periods across our staff. For example, the latest PhD studentship led by **Woodman** is the fifth funded by the ECB spanning a 12-year period, enduring across three different ECB Heads of Science and Medicine. Similarly, an initial collaboration with Kings College London, begun in 2008, has endured and expanded into relationships with the Wales Kidney Research Unit and the UK Kidney Research Council Health and Wellbeing Clinical Speciality Group now chaired by **Macdonald**. These contributions have generated project grants and fellowships funded by the National Institute of Health Research (NIHR).

Enduring and productive partnerships with external collaborative partners are guided by the core value of providing *evidence-based solution-oriented research* to organisations linked to sport and health, government agencies, charities, the private sector, as well as to the general public. To achieve this, we engage key stakeholders in a range of activities including dialogue, policy reports, relationship building, presentations, and other report formats. Staff within the School have also received specific media and impact training to better steer their interactions and have been in demand by various outlets (e.g., BBC, Sky Sports, UK and Welsh Government).

### **Research integrity, data management and open access**

Bangor University complies with Universities UK Concordat to Support Research Integrity, and has established structures to support effective research governance and ethics. Research ethics training is provided and supported by University courses but developed further in both our PGR and staff training processes. SSHES's research portfolio involves volunteer participants recruited from sports populations (amateur and professional), local student and community populations, and the military services; as well as patients recruited through NHS clinical services. Consistent with best practice, we seek to protect both participants and researchers by mitigating the risks of harm appropriately while continuously enhancing and monitoring ethical and scientific quality. The SSHES Ethics and Governance Committee reports to the University Ethics Committee, and evaluates researchers' protocols against relevant frameworks as set out by the BPS, NHS, Ministry of Defence, UKRI and EU funders, and all relevant legislation (e.g., data protection). We encourage preregistration of study protocols and the use of public repositories for data sharing (e.g., using US National Library of Medicine, As Predicted and the Open Science Framework). All clinical trials are preregistered and published in journals that expect preregistration. We promote the prompt publication of research findings (as papers and conference seminars). Publication is undertaken in line with the University Open Access Policy.

## 2. People

### Staffing strategy and development

#### Strategy

The commitment of SSHES to supporting research excellence through appropriate high-quality staffing is evidenced through: (i) the planned appointment of, and investment, in early-career researchers who show exceptional potential (**Blanchfield, Gallichio, Jones, Mee, Sandoo**); (ii) prompt promotion of future research leaders to Senior Lecturer (**Beattie, Lawrence, Oliver, Roberts, Sandoo**); (iii) promotion to Reader (**Oliver**) and Professor (**Callow**) for senior staff who have developed their research leadership; and (iv), where appropriate, retention of eminent researchers as Emeritus Professors (**Hardy L**). When appointing new members of staff, we take particular care to consider how candidates will complement and add value to intra- and inter-group collaborations. Thanks to our recruitment strategy, we have sustained a dynamic research-focused School: the mean age of staff is <43 years old, with only one researcher who will reach retirement age before the next REF2028 exercise.

#### Succession planning

We take succession planning and the continuity of our research groups seriously. We have an established tradition whereby senior researchers provide mentorship and guidance to colleagues to foster continued effective leadership and planning. In several instances, this allowed smooth and effective transitions with changes of role or departures (e.g. **Hardy L, Walsh**). As a result, some of our staff have taken on major academic leadership roles (e.g., **Macdonald** as Head of School; **Callow** as Pro-Vice Chancellor). Furthermore, we seek to emphasise the development of research leadership by encouraging junior and senior principal investigators to co-lead our collaborative projects with industry (e.g., English and Wales Cricket Board, Ministry of Defence, Rugby Football Union, Sport Wales, UK Sport), facilitating strong mentorship on strategic and day-to-day issues involving both internal and external personnel.

#### Developmental support

Staff development is supported by specialised seminar series (within each research group and across SSHES as a whole) involving external and internal speakers. This includes research assistant and PGR presentations, regular journal clubs, and monthly research group meetings that focus on project proposals, grant activity, and impact. All staff can participate in a School and/or a University mentoring system that provides individualised, ongoing support and guidance provided by another senior colleague (e.g., Professor/Research Group Lead).

As part of the University's annual professional development review scheme, all staff engage in the setting of research-related targets aligned to SHES strategic goals that are agreed upon and evaluated. Bangor University's study leave programme provides opportunities to develop research projects, with 14 periods of six-month research study leave having been awarded in this REF period. Also, we promote "mini sabbaticals", typically lasting 4–6 weeks, that enable staff to consolidate research progress at particular times in project cycles. New and early career academic staff are provided with additional support (named teaching and research mentors), reduced teaching and administration loads (for two semesters), and priority for School-funded PhD studentships (i.e., 11 awarded in REF period). Funding opportunities for staff development in impact have included our school Innovation Fund as well as the University's ESRC Impact Acceleration Award fund. These have been used to facilitate knowledge-exchange activities focusing on talent identification and development (e.g., England and Wales Cricket Board, Weightlifting Wales), preparation for Major Games (e.g., Gold Coast 2018 Commonwealth Games; Sport Wales), and safer driving behaviour (Imagitech Ltd). Finally, all staff and research students are funded to attend and present their work at international conferences.

The School engages in annual internal assessments of outputs to provide developmental feedback. Funding applications are reviewed through an internal peer-review process, providing feedback to strengthen proposals before submission. Further support in the form of continuing professional development is provided to research staff through in-house programmes of

activities. For example, biannual research away days have focused on rolling REF reviews, research ethics, and governance as well as dissemination of multi-level and pattern recognition analysis procedures; programming in R; cardiovascular ultrasound training; MRI and brain blood flow analysis. Lastly, value is added to the School's research environment through the support for visiting researchers to SSHES (approx. one per year) and the inclusion of honorary research positions enabling the maintenance and expansion of our research expertise.

### **Support and promotion of equality and diversity**

SSHES is committed to all aspects of equality, diversity, and social inclusion as embedded in the mission statement of Bangor University. This commitment is aligned with pursuing Athena SWAN charter principles. SSHES was the first in Bangor University to be awarded specific recognition. For six out of the seven years of the REF cycle, we have operated with Bronze Award status and offered mentorship to other Bangor University Schools for their own successful award applications. Currently, 42% ( $n = 20$ ) of our PGRs are women and 42% of staff appointments within the school were female during this REF cycle. These appointments speak directly to the School's commitment to equality and diversity (e.g., **Jones, Sandoo**); as does our co-funding of a collaborative ESRC PhD with UK Deaf Athletics. Senior management roles within the School/College held by our female researchers (**Callow, Gottwald**) provide strong role models for others. Furthermore, **Woodman**, and more recently **Jones**, sit on the University level Athena SWAN working group and two SSHES students have received Women in Science scholarships awards (in 2016 and 2017).

Other school-specific steps that support our commitment and promotion of equality and diversity include the appointment of a male Champion for Change; ensuring, as far as possible, gender balance in staff recruitment and appointment process; increased involvement and visibility of female and other under-represented groups at School Open Days; sensitive PGR allocation to offices, particularly relevant for International PhD researchers; meetings and seminars scheduled within core business hours (10:00-16:00); a multi-faith reflection/prayer room; breast feeding and unisex nappy changing facilities; personal professional development accounts for all staff; Welsh translation services for the School research seminar series; the availability of financial support to facilitate external female, LGBT, and BAME researchers to present in the School research seminar series; and the joint use of laboratory equipment by BSc, MSc project and PGR students and staff colleagues. Evidence of progress is indicated by **Sandoo** who has been promoted to Senior Lecturer and **Callow** who has been promoted to Senior Lecturer and Professor (Dean and then Pro-VC). All of our PGR prizes for excellence in this cycle have been awarded to female students.

### **Postgraduate researchers**

That the Director of PGR Studies is a permanent member of the School's Strategic Management Group speaks directly to the commitment of the School to its PGRs. We have a vibrant body of enthusiastic aspiring researchers from domestic, EU and non-EU international backgrounds, working part- and full-time, in laboratory and field based, and in basic and applied science. Students are self-funded, internally-funded (SSHES) or externally-funded. The headcounts of PGR students (including MRes) for the years 2014/15 to 2019/2020 show growth from 31 to 47. The number of doctoral degrees awarded has increased by 115% to 56 in this cycle compared with 26 REF2014 and is 3.29 per staff head count (and 3.33 per staff FTE).

The School maintains the baseline number of PGRs by school-funding at least two PhD studentships per year in addition to match-funding externally funded students and attracting external funding for PGRs. This commitment extends to match-funding for all UKRI/ESRC DTP PhD studentships. Consequently, we have invested nearly GBP1,887,090 over this REF cycle to support PGR activities. SSHES leads the ESRC – Doctoral Training Pathway for Sport and Exercise Sciences, involving CMU and Swansea University, and has established the annual pan-Wales PGR conference for Sport and Exercise Sciences. Our students are also well-represented in the College of Human Sciences PGR multi-disciplinary conferences. Such initiatives afford our PGRs excellent learning opportunities to interact with researchers from other Universities and Schools. Importantly, the School's PGRs appreciate such initiatives; “*The*

*Pan-Wales Sport Science Conference is an excellent way to develop and network. Similarly, the annual conference travel budget given by the department is essential.” (PRES, 2018).*

Formal interactions between PGRs and established researchers within SSHES are fostered by the activities outlined in the staff section above (e.g., research group seminars and meetings to discuss research proposals, grant activity, impact) but also SHES PGR Away Days. Staff who embark on research degree supervision for the first time complete an induction programme before joining supervisory teams. In close alignment with established good practice across the sector, and compliant with the QAA Code of Practice, they join supervisory teams with at least one other experienced supervisor to maximise mentorship opportunities. At present, **all** staff members are engaged in PGR supervision and **all** supervise on externally funded studentships. PGR supervisory teams include two supervisors (with relevant research interests), reinforcing the collaborative research culture within SSHES and enhancing the training experience.

The success of our approach is perhaps best illustrated by the supervisory arrangements utilised on the UK Sport-funded Pathway-to-Podium project, a prospective multidisciplinary follow-up to the Great British Medallists Project; one of our Impact Case Studies. In this project, three PGRs working within five Olympic sports measure psychosocial variables, practice and training behaviour, and the health of athletes on talent development programmes. In addition to regular supervisory tutorials, the PGRs have weekly meetings with their Bangor supervisors, the co-PIs, and their more applied English Institute of Sport supervisors. This type of supervisory integration is mirrored by two further PhD projects funded by Manchester City FC, and the NHS in which SSHES PGRs operate to translate empirical research into practical solutions for external partners. PGRs have been integral to the production of 98 peer reviewed papers in the current REF cycle, and more than 70% of the outputs submitted for REF2021 were co-authored by PGRs. These outcomes provide excellent training in research methods and data analysis and make a very meaningful contribution to the vibrancy of our environment.

The recruitment of postgraduate researchers to SSHES has been supported by a portfolio of funding arrangements. In this REF cycle, 20% of PGR students are funded through external, industry-based partnerships. Five PGRs have been supported through ESRC funding and 13 postgraduate researchers have been funded by the European Union through Knowledge Economy Skills Scholarships (KESS). External funding for PGRs from another 13 sources that include UK Sport, England and Wales Cricket Board, Rugby Football Union, Global City Football Group (Manchester City FC’s ownership group), the UK’s Ministry of Defence, Defence Science and Technology Laboratory, and the National Health Service, the national governments of Kuwait, Saudi Arabia, Iran, and United Arab Emirates, and Blue Sky charity. Self-funded PGRs have also been recruited internationally from China, Hong Kong, Iran, Iraq, Israel, Kuwait, Malta, Saudi Arabia, Singapore, and Switzerland.

Just like school staff, all PGR students receive an annual personal budget to fund specific research training opportunities and to present their research at national and international conferences. To help further their research training and prepare our PGRs for these conferences, they present at the College of Human Sciences’ (Bangor University) annual PGR conference as well as at the Sports Science Pan-Wales PGR conference. Early career researcher conference awards have been won at European Federation of Sport Psychology, 2019; Hypoxia, 2017; Experimental Biology, 2019; Physiological Society, 2019.

Finally, the School attracts PGRs worldwide. For example, during this REF period, PGRs based in Brazil, Canada, New Zealand, Holland, Italy, and Austria arranged extended visits to SSHES for upskilling. Further evidence of the high-quality research training is demonstrated by the British Psychological Society awards for best PhD thesis from the British Psychological Society in 2019 and best PGR student across Bangor University from Draper’s Company in 2018. Our PGRs are in demand and have gone on to work in other academic institutes in the UK and worldwide, the public sector and the NHS, as well as in high-profile industry organisations such as the NFL’s Cleveland Browns, England and Wales Cricket Board, English Institute of Sport,

Danone Nutrition, Football Association, GB Hockey, Manchester City Football Group, Mapei, Middlesbrough Football Club, Phillips, Rugby Football Union, and UK Sport.

### 3. Income, infrastructure and facilities

Spend has increased markedly since REF2014; by 95% from GBP1,767,710 to GBP3,438,688. Breaking this down across sources illustrates the importance of end-users in our research, with spend from UK industry, commerce and public corporations increasing very substantially from GBP133,573 to GBP1,925,079. We have also succeeded in accessing EU government sources with an increased spend from GBP209,037 for REF2014 to GBP498,643 for REF2021. A hallmark of our research activities is repeat funding, highlighting external partners' satisfaction with the work produced. This is true across all three research groups in the School. For example, as we describe below, IPEP group's continual and productive relationship with the England and Wales Cricket Board for more than 12 years.

#### Major grant awards

The PAWB group has completed health-oriented projects addressing chronic conditions across the lifespan. **Macdonald** has led our work to innovate and then evaluate the benefits of physical activity and quality of life in patients living with kidney disease. This has included participation in two large multi-centre trials: The National Institute for Social Care and Health Research-funded PEDAL trial (led by King's College London and including collaborators from Queen Margaret, Edinburgh and Leicester Universities) and the BISTRO Trial (led by Keele University with Birmingham and Salford Universities) (value to Bangor of GBP170,000). Both projects have been supported locally by awards from the Betsi Cadwaladar University Health Board (BCUHB) and Welsh charity-funding (Blue Sky/Awyr Las; GBP58,000). The PAWB group has secured funding for research in blood vessel function in rheumatoid arthritis (value of GBP68,000; **Sandoo, Moore**) and in breast cancer (Tenovus; GBP13,000; **Sandoo**); and physical activity in babies and toddlers (Healthy and Active Wales Fund/Babi Actif; GBP25,000; **Macdonald**).

**Oliver** and **Walsh** have continued a Bangor-led and Ministry of Defence-funded investigation (with the Universities of East Anglia and Manchester) into the benefits of Vitamin D supplementation for health and performance in military personnel, securing further a GBP322,000 to Bangor in 2015 (on top of an original award of GBP994,000 in late 2013). **Walsh** has investigated the effectiveness of the "hot bath" acclimatisation strategy; initially with athletes and then extended to military personnel (Ministry of Defence; GBP201,000). This innovative and low-cost approach of acclimatisation was used to help prepare Welsh athletes for the Gold Coast Commonwealth Games and was used by the Union Argentina de Rugby, Scottish Rugby, and Welsh Rugby Union in preparation for the 2019 Rugby World Cup, as well as by GB Modern Pentathlon. **Oliver** and **Walsh** have also been part of a multi-centre study with Loughborough and Stirling universities that developed a novel index of the hydrating qualities of different drinks (value to Bangor of GBP64,000 out of GBP275,000 from the European Hydration Institute). This project offers another physiology-specific illustration of our approach to partnership and dissemination as this project was a development of an earlier piece of hydration-related research, originally funded by European Hydration Institute and Hydra DX to **Oliver, Owen**, and **Walsh**. This strand of research continues now under the leadership of **Oliver**.

The Pathway-to-Podium project (**Lawrence, Woodman, Hardy L, Hardy J, Gottwald, Roberts, Oliver**) is an interdisciplinary ESRC-UK Sport collaboration (GBP235,000) and is a prospective continuation of the highly influential UK Sport funded "Great British Medallists Project" completed in 2013 and led by Bangor. This project addresses the interactions between personal, coach, and pathway factors that impact on athlete progress and well-being. The current phase of the project involves six staff from the School's Institute for the Psychology of Elite Performance and Extremes Research Groups, three full-time PhD researchers, two English Institute of Sport staff members, and five National Governing Bodies. IPEP's research expertise in talent development has also produced funded studentships in rugby (GBP106,000; Rugby Union Football; **Roberts, Hardy L**), weightlifting (Weightlifting Wales/KESS; spending GBP61,000; **Gottwald, Lawrence**), and in football (GBP214,000; Global City Football Services (owners of Manchester City Football

Club; **Callow, Hardy J**) over seven years involving Manchester City and Melbourne City (Australia) academies. Finally, **Hardy J, Lawrence, Roberts** and **Woodman** have successfully sustained the partnership developed by **Hardy L** with the England and Wales Cricket Board funding (GBP124,216) to fund five studentships on team effectiveness (e.g., BPS awarded best PhD thesis of the year 2019) and talent development. This programme has produced “spin-off” bespoke projects at professional county and senior national levels with interdisciplinary post-doc support. Other elite sports interdisciplinary projects include an English Institute of Sport-commissioned psychophysiological investigation of elite coaches’ experiences and reactions to the stress of major tournaments (GBP60,000; **Blanchfield, Cooke, Woodman, Hardy L**).

Complementing the interdisciplinary research in elite sport produced by our researchers is the health-oriented research in neurofeedback and Parkinson’s disease (value of GBP57,000, 2015; **Cooke** funded by BCHUB) and physical literacy (GBP55,000; Sport Wales; **Gottwald, Macdonald**). Moreover, in 2017, IPEP secured funding for a two-year post-doc from AXA insurance (GBP104,000; **Cooke, Woodman**) to develop a novel eye-gaze perceptual training strategy for reducing the risk associated with road accidents due to driver error. Utilising a rigorous interdisciplinary approach, it then assessed the effectiveness of this training. Finally, a newly funded PhD studentship from Bangor University’s Great Heritage Fund (GBP44,000; **Macdonald, Oliver**) has facilitated interdisciplinary collaboration between the School of Psychology and our Extremes Research Group, through the integrated use of our altitude environment chamber and the School of Psychology’s MR scanner.

### Infrastructure

SSHES researchers can bid internally from a budget of GBP25,000 per annum to support staffing, equipment, and consumables. This has also enabled the recruitment of two part-time Research Officers. SSHES is committed to the strategic support of its staff via internally funded PhD studentships, which have totalled GBP887,000 over the REF cycle.

Three overarching structures aid the School’s research impact and engagement with industry. SSHES, Swansea University and the University of South Wales cofounded The Welsh Institute of Performance Science in 2015 (with Welsh Government and Sport Wales funding) to facilitate research and impact relevant to Welsh elite sport in preparation for Wales’ historically most successful 2018 Commonwealth Games and beyond. SSHES researchers have used KESS PhD and MRES studentships to develop 10 knowledge-exchange partnership research projects with 8 different local and national company partners (Ryobi Gogledd Cymru, Mountain Training UK, Outlook Expeditions, Outdoor Partnership, Surf Snowdonia, Ynys Mon Island Games Association, Youth Justice Service, Welsh Weightlifting, GBP349,000). Further, the School’s work with the ESRC Doctoral Training Programme (5 PhD studentships GBP193,000). Finally, we have funded impact-related activity from the ESRC Impact Acceleration Award to foster collaboration with Sport Wales, UK Sport, NHS, and new industrial partners in Imagitech LTD and NRS Healthcare (GBP78,000).

### Facilities

Coordination with other Schools within the College of Human Sciences has enabled us to utilise facilities not otherwise available to our researchers. Examples of this infrastructure include a Faraday cage, and a functional magnetic resonance imaging unit containing a recently replaced research-dedicated Philips 3T Achieva MR scanner (**Oliver, Macdonald**), MRI compatible EEG, transcranial magnetic stimulation (TMS), stimulus presentation systems, and eye-tracking systems (**Cooke, Gottwald, Hardy J, Lawrence, Woodman**); all exclusively protected for research purposes. Since 2014, the university has invested more than GBP1,304,000 to maintain and enhance SSHES infrastructure, facilities, and research-related equipment. These now include five exercise physiology laboratories; two environmental chambers (one with altitude capabilities); a dual-energy X-ray absorptiometry laboratory and an underwater weighing laboratory for body composition assessments; a cell biology laboratory; a biochemistry laboratory; a 12-camera motion analysis laboratory; four motor control and learning laboratories; a psychophysiology and electrocardiography suite; a social psychology laboratory and interview suite; and a “live-in” laboratory with a kitchen and space for six beds. Unusually for the sector

perhaps, our physiology and psychology research activities are each supported by a dedicated and highly effective technician with skill sets originating in sports science and electrical engineering to create bespoke high-tech equipment and information technology. Between them, they have >40 years of experience helping to meet the Schools' research technical challenges.

#### 4. Collaboration and contribution to the research base, economy and society

Collectively, SSHES staff members make a major contribution to the discipline. For example, the previously described externally funded physiology projects have all required staff to cultivate strong working relationships with other research institutes. This is mirrored by the School's psychologists' highly effective partnerships with research end-users in elite sport (e.g., England and Wales Cricket Board, English Institute of Sport, Global City Football Services, Rugby Football Union, UK Sport). The Welsh Institute of Performance Science, the EU-funded Knowledge-exchange Studentship Scheme, and ESRC Impact Acceleration Award structures and funding have all facilitated research collaboration outside of academia.

##### Research collaborations

Formal external collaborations have been created with universities in the UK and internationally. For instance, 9 staff members (54% of current staff) have been Visiting Professors abroad at universities in Australia (Curtin, **Beattie**), Austria (Innsbruck, **Oliver, Moore**), Canada (Toronto, **Macdonald**; UBC, **Oliver** and Western, **Roberts, Callow**), Malaysia (University of Malaysia, **Callow**), New Zealand (Waikato, **Cooke**), Peru (Universidad Peruana Cayetano Heredia, **Moore**), as well as the USA (Texas, **Moore** and Connecticut, **Walsh**). Moreover, international researchers from Austria, Canada, China, New Zealand, Peru, and Saudi Arabia have had extended study periods in the School. In addition to the previously identified research collaborations, SSHES staff members conduct research with colleagues who are members of internationally excellent research groups at Birmingham; Leicester, Exeter; Loughborough; Southampton; University College London; Nice, Paris-Sud (France); Hannover (Germany), Curtin (Australia), British Columbia, Calgary, Western, Windsor, and Alberta (Canada); Santa Cruz (Brazil); Maastricht (Netherlands), Connecticut (USA). In total, the School has active research collaborations with 23 UK and 40 international research institutes, which help to further the reach of its researchers as well as enrich the research culture in Bangor.

##### Broader contribution to the research community

##### Editorial contributions

The contribution made by researchers in SSHES has increased by 82% (11 to 20 journals) since REF2014 so that Bangor staff now have extensive involvement in editorial activities across many of the sector-leading journals. 11 staff members have fulfilled key roles during the period:

1. **Associate Editors:** *Applied Physiology, Nutrition and Metabolism* (**Oliver**); *Exercise Immunology Review* (**Walsh**); *Journal of Applied Sport Psychology* (**Hardy J**); *Journal of Sport and Exercise Psychology* (**Hardy L**); *Journal of Sports Sciences* (**Walsh**); *Journal of Sport Sciences USA* (**Lawrence**); *Perceptual and Motor Skills* (**Beattie**); and, *The Sport Psychologist* (**Woodman**).

2. **Guest Editors:** *Sport Exercise and Performance Psychology* (special edition on psychophysiology in sport, **Cooke**); *The Sport Psychologist* (special edition on self-talk in sport, **Hardy J**); and, *Encyclopaedia of Sport Psychology* (section editor on personality in sport, **Roberts**).

3. **Editorial Board members:** *Athletic Insight* (**Hardy J**); *European Journal of Sport Science* (**Hardy L**); *Exercise Immunology Review* (**Walsh**); *Current Issues in Sport Science* (**Hardy L, Woodman**); *Frontiers in Psychology* (**Cooke**); *High Altitude Medicine and Biology* (**Macdonald**); *Journal of Sport and Exercise Psychology* (**Hardy J, Markland**); *Medicine and Science in Sports and Exercise* (**Walsh**); *Movement and Sport Sciences* (**Hardy L, Woodman**); *Movement Science and Sport Psychology* (**Cooke**); *Pamukkale Journal of Sport Sciences* (**Beattie**);

*Psychological Reports* (**Beattie**); *Psychology of Sport and Exercise* (**Woodman**); and, *The Sport Psychologist* (**Roberts**).

### **Expert contribution to scholarly societies and agencies**

Thirteen staff undertake peer and expert reviewing for major funding agencies and Research Councils, an increase of 63% since REF2014. These agencies include: Arthritis Research UK; Australian Research Council (**Hardy L**); Biotechnology and Biological Sciences Research Council (**Kubis, Walsh**); British Academy (**Callow**); British Council (**Hardy L**); Czech Science Foundation (**Woodman**); Economic and Social Research Council (**Cooke, Roberts, Hardy L, Woodman**); European Commission Marie Curie Fellowships (**Cooke**); Flanders Research Council (**Oliver**); German Science Federation (**Roberts**); Health Research Board Ireland (**Oliver**); National Institute for Health Research (**Macdonald**); Heart Research UK (**Sandoo**); Kidney Research UK (**Macdonald**); Leverhulme Trust (**Kubis, Roberts, Woodman**); Marie Curie (**Roberts**); Medical Research Council (**Kubis**); National Institute of Anaesthesiology (**Oliver**); National Science Centre – Poland (**Oliver, Woodman**); NSERC Canada (**Moore**); Netherlands Organisation for Health Research and Development (**Kubis**); Research Grants Council – Hong Kong (**Hardy L**); Rheumafonds (**Sandoo**); Social Sciences and Humanities Research Council of Canada (**Hardy J, Hardy L**); Swiss National Science Foundation (**Hardy J, Kubis, Roberts**); and, Wellcome Trust (**Macdonald, Moore**).

Staff members from the school have had a direct influence on the strategic direction of subject associations/professional organisations: British Association Sport and Exercise Sciences (BASES; Conference committee member – **Beattie**); British Renal Society Rehabilitation Network (**Macdonald** – founding member); Expertise and Skill Acquisition Network (ESAN Committee Member – **Lawrence**); and UK Kidney Research Council Health and Wellbeing Group (**Macdonald**). **Beattie** and **Walsh** have also been recognised by the academic community and are Fellows of the British Association Sport and Exercise Sciences (BASES) and the American College of Sports Medicine (ACSM), respectively. **Beattie** led SSHES hosting the successful BASES Student Conference in 2017. Within the Welsh Institute of Performance Sciences, **Beattie, Blanchfield, Gottwald** and **Oliver** have held discipline-specific lead roles.

All established SSHES researchers have acted as external examiners for PhDs at UK and international universities (e.g., Australia, Canada, France, New Zealand). SSHES researchers (e.g., **Callow, Hardy L, Walsh, Woodman**) have also served as reviewers for the discipline's reader and professorial applications at universities in the UK (e.g., Bath, Birmingham, Brunel, Cardiff Metropolitan, Edinburgh, Exeter, Loughborough) and overseas (e.g., Copenhagen University, Singapore's Nanyang Technological University, Seoul National University, University of British Columbia, and University of Western Australia). Furthermore, in 2015, **Hardy L** facilitated UK Sport's Strategic Planning Group through a series of meetings over 9 months to develop a Ten Year Strategic Plan for the development of high-performance sport in the UK. He has also been a reviewer for distinguished professor career awards of merit for Canadian (Western) and Australian (Griffith) universities.

### **Keynote and plenary presentations**

SSHES researchers are well-represented at many subject-focused research conferences. The number of staff members delivering high-profile research talks has increased 400% since REF2014. As well as commonly contributing to invited symposia at conferences (e.g., FEPSAC; **Beattie, Cooke, Hardy J**), 10 members of staff have made **keynote and plenary lectures/presentations** to national and international conferences including the Annual Dialysis Conference (**Macdonald**, 2017), Asian Federation of Sports Medicine Congress (**Beattie**, 2019), Australasian Skill Acquisition Network (**Cooke**, 2019), European Peritoneal Dialysis Meeting (**Macdonald**, 2017), Expertise and Skill Acquisition Network (**Lawrence**, 2016), German Respiratory Physiology Conference (**Kubis**, 2016), Inaugural Global Renal Exercise Symposium (**Macdonald**, 2019), International Sports Science Congress (**Hardy J**, 2016; **Woodman**, 2015), Sport and Exercise Science NZ (**Cooke**, 2019), Updates in Chronic Kidney Disease National Conference (**Macdonald**, 2014), World Hydration Congress (**Oliver**, 2015), Welsh Exercise

Medicine Symposium (**Macdonald, Sandoo**, 2018), and British Association of Sport and Exercise Sciences Conference (**L Hardy**, 2015, 2018).

In addition, **journal editors have showcased our published studies as exemplifying excellent research** (e.g., the APA journal, *Sport Exercise and Performance Psychology* highlighting **Beattie** and **Woodman's** work on the negative effects of self-efficacy), while other projects have received national and international acclaim. For instance, Hardy L, **Barlow** and **Woodman's** UK Sport funded Great British Medallist project was a Times Higher Education's (2015) runner-up for the UK's best research project in the social sciences. A third psychology-specific example is **Cooke** and **Woodman's** five study paper deemed to be the best published in the discipline's flagship journal (*Journal of Sport and Exercise Psychology*) for 2019. Meanwhile, in physiology, **Oliver** and **Blanchfield's** paper on napping was shortlisted for the 2018 paper of the year by the *European Journal of Sport Science*.

While the above achievements and partnerships recognise recently conducted research and bode well for imminent research projects, the development of researchers and research talent is another strength associated with SSHES. **Hardy L** has supervised and mentored Professors in at least four UK universities (Bangor, Bournemouth, Cardiff Met, South Wales) and at least four Performance Directors/National Psychology Leads in UK level national governing bodies for Cricket, Hockey, Speed Skating, Rugby, Football, and Tennis. Recently graduated PGRs have gone on to hold academic positions in Sweden, Turkey, the USA, Thailand and Switzerland. One PGR student has gone on to hold a NASA-funded post in the Institute for Exercise and Environmental Medicine in Dallas (USA), won the *Journal of Physiology* Early Investigator Prize, and accepted a full Professorship in Austria aged only 35 years old. Due to the applied nature of sports science, research skills developed through supervision and collaboration with our staff have also influenced practice within the ECB (e.g., **Barlow's** involvement with player and coach preparation for major events) and elite UK sport more widely (see Impact Case Study). This latter contribution straddles research and practice, with two PGR students participating in UK Sport's Culture Project to research and advise on appropriate cultures across British Olympic sports. This impactful project was partially based on the findings of the GB Medallist project (**Barlow, Hardy L, Woodman**) and a culture-specific scoping project carried out in SSHES by **Hardy L** and **Roberts**. One of these students was appointed UK Sport's first Lead for Mental Health in 2018.

#### **Leading contribution beyond academia**

Funders now encourage researchers to consider impact in the formulation of research projects and not just at the dissemination stage. This has meant involving stakeholders and research users in the development of both the research questions and the research methods used. Our enduring partnerships with ECB, UK Sport, the MoD indicate that we already follow this model. IPEP's (**Hardy L, Hardy J, Lawrence, Roberts, Woodman**) strong partnership with the ECB exemplifies this and has resulted in five funded PhD studentships as well as the creation of a new post within their Science and Medicine Unit. Each of the funded PGRs and respective knowledge generated has been integrated into the structure of the ECB to optimally inform the organisation. For example, all Level 3 and 4 cricket coaches in the UK have been upskilled with this new and cricket-specific team effectiveness research knowledge. A second illustration involves changes to how "scouting" and talent development is now carried out. Due to the success and subsequent demand of an IPEP-developed mental toughness training programme, a similar programme was conducted at the County level of cricket.

A noteworthy and particularly innovative example of this was a Bangor-led project that took an interdisciplinary approach to build upon the original mental toughness project to develop individualised resilience training. This Individualised Pressure Training project was conducted in close collaboration with the new performance psychologist as well as the Head of Science and Medicine, the National Lead for Psychology, and National Lead coaches for each cricket discipline. IPEP members supervised and contributed expert input enabling effective multidisciplinary data collection, analysis, interpretation, and implementation. This unique training programme was initially conducted with the Men's Lions (developmental) National team

and then the Women's Senior National team. Its impact was most obvious with regards to the shaping of how the Men's Senior International players prepared for their winning 2019 Cricket World Cup campaign. Corroborating the high value in which the ECB rated this project, the Head of Science and Medicine reported it to be the best and most exciting sport science intervention that the organisation had conducted to date.

The numerous examples of externally-funded, impact embedded projects listed in Section 2, alongside our two submitted Impact Case Studies, outline the scale and scope of SSHES' research to the contribution, and upskilling of, organisations outside academia. Our PGR projects have provided insights to help businesses including Surf Snowdonia, Outlook Expeditions, and Snowdonia Watersports to innovate their products. These businesses have helped turn North Wales into the adventure capital of Europe, placing 4<sup>th</sup> in the 2017 Lonely Planet top 10 regions of the World to visit, contributing ~GBP500,000,000 to the Welsh economy and supporting ~800 full-time jobs. Presentations, reports, and guidance provided by SSHES staff during this REF cycle illustrate how our contribution is underpinned by **effective communication/dissemination**. For instance, evidence-based, solution-focused guidance has been provided in both health domains (e.g. exercise and arthritis texts including ACSM's Guidelines for Exercise Testing and Prescription) and sport domains (e.g., **Lawrence** advice on the updating of the WRU's Level 1, 2, and 3 coaching awards) domains. Seven staff members have provided keynote and plenary lectures/presentations to national and international practitioner-oriented conferences such as the Australian Institute of Sport: World Class to World Best (**Cooke**, 2019), England and Wales Cricket Board Science and Medicine Conference (**Hardy J**, 2016; **Hardy L**, 2014, 2015; **Woodman**, 2017), England and Wales Cricket Board Coaching Conference (**Lawrence**, 2016), English Institute of Sport Conference (**Oliver**, 2017), Global Renal Exercise Network meeting (**Macdonald**, 2019) and UK Sport World Class Performance Conferences (**Barlow**, 2014, 2015).

Staff members have also made contributions to more popular outlets that include BBC Radio (**Jones**, **Woodman**, **Macdonald**), BBC TV (**Beattie**, **Roberts**), BBC News website (**Macdonald**), Channel 4 Television (**Woodman**, **Macdonald**), Sky Sports TV (**Woodman**), S4C TV (**Beattie**, **Hardy J**, **Roberts**, **Woodman**), newspapers (**Lawrence**, including a front page article on The Daily Mail, **Kubis**), and a Tedex Talk (**Roberts**). We have actively contributed to the Welsh European Funding Office Work-based learning programme in Health & Wellbeing provided by the College of Human Sciences (Psychology, Health Sciences, and SSHES) to upskill the Wales health-oriented workforce. The courses were validated by Bangor University and were an opportunity for employees to access higher degree training. The overall programme worked with 78 private companies across North Wales with SSHES leading tuition on nutrition and hydration, leadership and management, and effective coaching.