Institution: University of South Wales

Unit of assessment: C24 Sport and Exercise Sciences, Leisure and Tourism

1. Unit context and structure, research and impact strategy

Unit context and structure

The Sport, Health and Exercise Sciences (SHES) Research Group is part of the School of Sport, Health and Professional Practice, based in the Faculty of Life Sciences and Education at the University of South Wales (USW). The **SHES Research Group** comprises 12 academics (9.9 FTE) centred on two integrated, multi-disciplinary themes – **Sports Performance** and **Vascular Health** – that have achieved global recognition and considerable regional, national and international success since the REF2014 submission. The Unit of Assessment (UoA) has enhanced its profile over the REF period by expanding areas of established strength and research leadership within sport, health and exercise science (comprising physiology and psychology) and the social sciences of sport (sport coaching). Strategic staff appointments, combined with infrastructural and analytical developments, have led to significant improvements in grant capture and world-leading outputs underpinned by the UoA's philosophy of 'real-world' translational impact.

The **Sports Performance Group** (led by **Cropley** & **Shearer**) has six members (**Cropley, Mullen, Rainer, Shearer, M Williams, T Williams**), an applied theme, and takes a practical approach to improving elite athlete performance and promoting physical activity among adolescent performers. The **Vascular Health Group** (led by **Bailey**) also has six members (**Bailey, Ainslie, Fall, Marley, New, Rose),** a biomedical theme, and focuses on the vascular benefits of exercise throughout life. These two main themes are strategically supported by specialist research disciplines focused on: (i) Clinical Neuroscience/Vascular Physiology; (ii) Sport Psychology; (iii) Injury, Training Load and Monitoring, Rehabilitation; and (iv) Sports Coaching and Development. Each discipline is led by a Research Professor (**Bailey**, **Mullen**, **Shearer** & **Cropley**) who provides day-to-day management guided by the research strategy.

As part of the Unit's impact strategy, direct engagement with research users regionally, nationally and globally is also promoted through strategic collaboration with the Welsh Institute of Performance Sport (WIPS), of which the UoA is both a founding member and academic partner (**Shearer**). WIPS focuses on multi-disciplinary, world-leading, applied science projects that enhance the performance of Welsh athletes and businesses. It is a three-way collaboration between Sport Wales, leading sport scientists and industry partners (Section 3). The Centre for Football Research in Wales (CFRW), led by USW (**Cropley**), also works with the Football Association of Wales Trust (FAWT) to promote multidisciplinary research into football to support best practice in areas including performance, player development and welfare, coach education, participation, and health. The Hamstring Strain Injury Research Group (HSIRG), founded by **M Williams** with collaborators from Queensland University of Technology and Australian Catholic University, was formed to address the widespread prevalence of hamstring injury and re-injury in team sports. To date, the HSIRG has produced an evidence-based framework to inform the diagnosis, prevention, and treatment of hamstring strain injuries and other common lower extremity muscle injuries in sport. The work of WIPS, CFRW and HSIRG ensures the UoA's research is addressing real challenges with a view to achieving impact across all sports in Wales, the wider UK and internationally.

The UoA has further expanded its research and reach through international collaborations with world leading free radical, vascular physiology and neuroscience specialists and organisations including the European Space Agency and MedGraphics. This has helped to integrate basic molecular science with functional physiology, providing unique mechanistic insights into the multidisciplinary bases that define sport, health and exercise sciences.

Research and Impact Strategy: The Past (2014-2021)
The strategies outlined in the UoA's REF2014 submission built on the unit's distinctive strengths. The overarching objective was for the UoA to become an internationally renowned specialist research group, recognised for its world-class research that improves sports performance and addresses societal challenges such as 'Healthy Ageing'. The UoA's (5) primary **Aims** for the period 2014-2021 were as follows:

1. **Increase external research income**: The multidisciplinary nature of the UoA's research, integrating clinical and applied interests, will present exciting new grant funding opportunities based on developing initiatives and priority areas.

2. **Expand on current infrastructure through research staff recruitment and novel analytical expertise development:** Through increased external research income, and strategic support from the Research Institute of Science and Health, the UoA will appoint Research Assistants (RAs) supported by Postgraduate Researchers (PGRs) to increase experimental 'throughput' and 'analytical expertise'.

3. **Further develop postgraduate provision, increase Early Career Researcher (ECR) support, and continue professional development of existing research staff**: This will be achieved through increased research income combined with the comprehensive support infrastructure provided by the Research Institute of Science and Health and informed by The Concordat.

4. **Continue to produce original, high-quality and peer-reviewed research outputs**: Given the UoA's contemporary research themes, members at all stages of their careers will actively be encouraged, mentored and trained to publish in the highest quality journals.

5. **Build additional capacity for delivering transformational impact:** Research will be aligned with the UoA's impact agenda a priori. Members will be actively encouraged, with the appropriate support, to engage with stakeholders and address external societal and health challenges. This will emphasise the wider significance and translational value of their research and achieve significant health, social and economic impact.

Reflection and Progress (2014-2021)
Underpinned by its world-class analytical infrastructure and expertise combined with strategic engagement with external partners, the UoA has developed new and important avenues of contemporary research:

Sports Performance: Members developed the promotion of health and wellbeing (including motor performance) through sports participation and conducted detailed research into biomarkers of sports injury, hamstring injury and rehabilitation, training load, and the optimisation of return-to-play strategies in contact sports. The latter has focused specifically on concussion, including novel molecular-haemodynamic measures of neurovascular unit function. Members have also advanced the understanding of specific mechanisms (e.g. reflective practice) and biopsychological interventions (e.g. biofeedback) that support the development of learning and performance in applied practitioners, coaches and athletes. This included novel advances in how the mechanisms of collective efficacy are conceptualised and subsequently used as interventions for high-performing teams.

Vascular Health: Members advanced understanding of the basic/clinical mechanisms underpinning ageing-induced cognitive decline, taking advantage of novel applied models of 'accelerated brain ageing' (long-term exposure to hypoxia and repetitive concussion) and neuroprotective countermeasures (brain targeted high-intensity interval training, HIIT). They have actively contributed to the clinical science underpinning the recent 'Class Action' in world rugby union (December 2020) highlighting the mechanistic link between recurrent concussion

and early onset dementia. They have also defined cardiorespiratory fitness threshold metrics with prognostic significance for postoperative survival in patients with cancer and vascular disease.

By capitalising on these new initiatives and priority areas, the UoA's research income increased by 87 % **(Aim 1)** over the current REF period, from a total of £127,783 for 2008-2013 to £239,173 for 2014-2021. This substantial rise in funding success and spending is directly linked to a significant increase in submissions to a broad range of external funding agencies, including: the Royal Society; Royal College of Surgeons; National Institute for Social Care and Health Research; British Heart Foundation; ADInstruments; British Oxygen Company; Canadian Institutes of Health Research; Canadian Stroke Consortium/Heart & Stroke Foundation; AstraZeneca Switzerland; Wellcome Trust; Knowledge, Economy, Skills Scholarships (KESS) projects; Welsh Government; A4B, and WIPS.

Infrastructure and analytical expertise have been expanded and developed (**Aim 2**) through new staff appointments and the focused development of existing staff. Postgraduate Researcher (PGR) recruitment and supervision has increased with the addition of new staff (**Cropley, Shearer, M Williams, Marley** and **T Williams; Aim 2**), driven by increased grant capture success and SWU's strategic investment in SHES (**Aim 3**). The widened staffing base, combined with additional infrastructure and analytical expertise (see later), have increased the breadth and depth of the UoA's research (**Aim 4**).

The **Sports Performance Group** has also expanded its research portfolio (**Aim 4**), that was originally limited to sport psychology in the REF2014, through the addition of new staff. Both WIPS (for which **Cropley** & **Shearer** are Research Steering Group Leads for Psychology and Coaching Science respectively) and the CFRW actively build links with Sport Wales and the Football Association of Wales Trust (FAWT). These links foster further applied research that positively impacts the practice of coaches and sports scientists working for the National Governing Body (NGB) and ensure that the interventions are implemented to benefit athletes competing on the world stage. This has resulted in the appointment of 4 PhD students. Five additional PhDs are funded through Knowledge Economy Skills Scholarships (KESS) in partnership with FAWT, Sport Wales Institute and Swim Wales. This provides unprecedented access to coaches, coach educators and mentors operating at sport's highest professional level.

Cropley's qualitative research expertise has helped expand the group's analytical capabilities (**Aim 2**), enhancing collaborative research with other group members (e.g. **Rainer**). **Cropley's** world-leading work on reflective practice underpins the British Association of Sport & Exercise Sciences (BASES) accreditation, FAWT's coach education portfolio, and UK Coaching's coach education and development resources, and supports new approaches to workforce development (**Aim 5**). **Cropley** has published novel and internationally-recognised research that has: (i) been the first to empirically identify relationships between reflective practice and enhanced service delivery effectiveness in sport psychology; (ii) discovered a direct relationship between sport coaches' ability to engage in reflective practice and the development of the personal characteristics required to positively adapt to stressors; (iii) produced the evidence required to inform the integration of life skill development into existing coach education qualifications; (iv) been the first to explore the impact of demographic and personal factors on the motivation and access to ongoing professional development of over 70,000 UK sport leaders to understand how wider participation in sport and physical activity can be improved; and (v) explored the importance of viewing sport coaches as performers and understanding the vital role psychosocial factors (including well-being) play in optimal coach functioning.

Shearer has continued to develop his research on collective efficacy in high-performing teams. He has led the development of published work that: i) identifies potential mechanisms that underpin the process of collective efficacy perceptions; ii) highlights how these mechanisms

further the understanding of group dynamics and the perception of important indicators of team performance; iii) has tested the utility and efficacy of observation interventions to enhance collective efficacy in team sports; and iv) has developed a shortened measure of collective efficacy suitable for real-time measurement alongside neuropsychological measures of collective efficacy. **Shearer's** group is the first worldwide to adopt a neuroscience perspective for collective efficacy and highlight how typically individual-based interventions can be used to improve collective efficacy in teams. **Shearer** is also part of an international team who publish on the characterisation and measurement of recovery from the demands of rugby union and football that has: i) characterised markers of physical recovery against specific game demands; ii) developed a psychological measure of recovery since adopted by researchers worldwide as a non-invasive biomarker; iii) measured the effect of competition demands on sleep; and iv) modelled worst case scenarios of physical demands in international rugby, and modelled game play characteristics that predict performance at a Rugby Union World Cup. Crucially, this research has been implemented by practitioners worldwide seeking to make performance gains in the teams they support.

M Williams' work on hamstring injury has also widened the international scope of the UoA's research impact. Impact on the scientific community's understanding of hamstring injuries and their reoccurrence (**Aims 4 & 5**) was generated through global collaborative research conducted by the HSIRG. This research, involving teams from the Australian Football League, Irish Rugby Football Union and numerous other professional football clubs and National Governing Bodies (NGBs), has: (a) established the nature and extent of the hamstring strain injury problem and the role of eccentric hamstring strength and the Nordic hamstring curl exercise in reducing hamstring strain injury risk; (b) established the validity and reliability of a novel hamstring strength testing device (NordBord) to measure eccentric hamstring strength and examine its role in reducing hamstring strain injury risk; (c) provided insight into the demands of the Nordic hamstring curl exercise and adaptations that occur as a result of performing it; and (d) improved product/resource development (NordBord) and the design of training and rehabilitation programmes. This research has been implemented by practitioners at the highest level of sport worldwide (e.g., Premier League, UK; NFL, USA; International Rugby and Football, UK; Australian Rules Football, AUS), with reports indicating significant impact on the prevention of hamstring strain injuries and improved rehabilitation efficiency (see **Impact Case Study**).

Mullen's work on sport psychology has continued to focus on anxiety and motor performance. Additional integration of **Shearer's** psychological expertise into the **Sports Performance Group** has helped further increase the number and quality of outputs. **Shearer's** impact-led work with Sport Wales resulted in bespoke psychological support for Wales' international coaches and performers, contributing to medal successes at both the Commonwealth and Olympic Games (**Aim 5**).

The **Vascular Health Group** continues to publish world-leading research in the most prestigious biomedical journals. **Bailey**'s group has published articles in The Lancet (impact factor 59), Lancet Neurology (impact factor 30) and Circulation (impact factor 23) – clear evidence of its research quality. **Bailey** has completed numerous 'first-in-human' studies (**Aims 4-5**) including: randomised controlled trial exploring the neuroprotective benefits of HIIT in humans; parabolic flight studies demonstrating that cerebral hyper-perfusion increases blood-brain barrier permeability that could be further compounded by exercise informing neurological risks associated with microgravity of deep spaceflight; free radical detection/molecular characterisation using novel spin-traps across the human cerebral circulation providing mechanistic insight into the local regulation of oxygen transport during exercise. **Ainslie** is Professor and Canada Research Chair at The University of British Columbia Okanagan, Canada and was returned to REF2014 (0.2 FTE) having collaborated extensively with **Bailey** since 2004. He has continued in his current 0.2 FTE role as a Professor contributing extensively towards mentoring of colleagues in **Bailey**'s laboratory focusing on the integrated redox-regulation of human brain blood flow. These collaborative

activities have led to international exchange of PGRs, published outputs and collaborative research grants.

Collectively, these activities have resulted in PGR exchange from Europe, Japan, Canada, USA, New Zealand, Australia and Europe (**Aim 2**), high quality research outputs (**Aim 4**), provided translational impact (**Aim 5**) and developed additional novel analytical expertise, further enriching the UoA's environment. In support, the UoA's two selected **Impact Case Studies** (**Cropley** & **Shearer**, **M Williams**) stand testament to how 'applied impact' is strategically embedded throughout the UoA's research work, highlighting the success of its multidisciplinary approach to developing and sustaining impact, taking full advantage of strategic funds and partnerships (e.g. KESS). Furthermore, **Bailey** has achieved significant impact by engaging with the public through the media highlighting the neurological benefits of physical activity across the lifespan, extreme physiology (e.g. high-altitude mountaineering, freediving, space travel) and complications associated with recurrent concussion (Section 4, **Aim 5**).

Research and Impact Strategy: The Future (2021-2027)
Given the research landscape's dynamic nature – notwithstanding the more recent challenges posed by COVID-19 – the UoA has regularly reviewed its research and impact strategy in accordance with USW's 'Research Strategy (2018-2028)' and '2030 Vision'. Building on established areas of research strength, the UoA has recalibrated its overarching objective to contribute to society through world-leading research that has translational impact. More specifically, its strategic aims for 2021-2027 include:

1. To further enhance the rigour, significance, originality and impact of our research outputs, using multidisciplinary approaches to investigate 'real-world' challenges that can be addressed through sport, health and exercise science.
2. To increase the translational impact of our work by building the activity and profile of our partnerships with regional, national and international external stakeholders. We intend to enhance current partnerships and develop new alliances.
3. To further develop our world-leading research environment by extending strategically defined priority areas focused on sport and Healthy Ageing (e.g. in response to Industrial Strategy Challenge Fund Healthy Ageing Challenge Framework).
4. To increase diversity through, for example, the appointment of more female staff, PGRs and related research that addresses gender inequality issues.

The UoA will also contribute to the wider (USW) Research Strategy/2030 Vision by focusing on the following targets, notwithstanding the inevitable challenges posed by COVID-19:

1. Promote, retain and recruit high-quality staff with significant responsibility for research (SRR).
2. Increase grant funding, specifically income that generates more world-leading outputs underpinned by translational impact that informs policy and practice.
3. Extend the recruitment of postgraduate students.
4. Provide all staff and students with high-quality support, training, development and dissemination opportunities, utilising our international collaborative research network.

Research and Impact Strategy: Delivery
The UoA's research and impact strategy is governed through the SHES group structure (**Sports Performance and Vascular Health**) and the associated subgroup themes, each led by an established Professor. Team meetings are held weekly. The Professors also meet quarterly with the wider senior academic management team (Dean, Head of School) to review progress against aims and key performance indicators. All members of staff have been aligned to a Sport, Exercise & Health Cognate Group (CG) led jointly by **Cropley** and **Shearer** as outlined in the institution-level environment statement (REF5a). The CG supports staff engagement in research (including those without SRR) and drives the SHES research

strategy. This means that all staff have a formal network through which research can be established, discussed, conducted and disseminated.

The Professors are responsible for the day-to-day oversight of research activities aligned to their specific research disciplines (**Bailey**: Clinical Neuroscience/Vascular Physiology; **Mullen** & **Shearer**: Sport Psychology; **Shearer** & **M Williams**: Injury, Training Load and Monitoring; **Cropley**: Sports Coaching and Development). In terms of governance, **Bailey**, **Cropley** and **Shearer** report directly to the Faculty Research and Innovation Committee chaired by the Faculty Head of Research and reports directly to the USW Research Committee. Committee outcomes are then reported directly to the Directorate, chaired by the Vice-Chancellor and Pro-Vice Chancellors to ensure accountability. Ethics oversight is governed by the Faculty Research Ethics Committee (**Marley**, **Shearer** & **M Williams** are members and/or have provided reviews) under the auspices of the USW Committee. PGRs are also administered at Faculty level, with ultimate oversight from the University's Graduate Research School. REF5a also provides detail on how all staff, including PGRs, are supported by central services to identify and apply for research funding, and through knowledge and exchange activities with a strategic focus on translational impact.

The importance of impact is mirrored in the UoA, where 'start with the end in mind' underpins impact development activity. Impact is a key part of the mentorship programme and central to discussions on grant and research proposals and outputs. Individual researchers must also create and manage their own impact activities using PURE, the University's online research repository. Staff development workshops familiarise and engage staff with the PURE system's impact module and demonstrate how a wide range of impact activities can be recorded. In addition to the activity at UoA level, the University also offers central support to develop the unit's research impact (REF5a). The UoA will extend the translational impact of its research by focusing on the priority areas led by members of the **Sports Performance Group** and the **Vascular Health Group**. The groups' research has particular potential to inform policy and practice, from the clinical to the applied performance environments. They will continue to seek to impact on sports policy through participating in stakeholder networks and associations and engaging with the public through the media.

Sports Performance Group: Cropley (**Impact Case Study** with **Shearer**) will continue research into developing novel understandings of mechanisms (e.g. reflective practice; personal characteristics) that enable effective service provision in coaching and sports science. He is currently engaged in ongoing work with UK Coaching to develop resources, driven by research, for its coach development and education offerings. These focus on reflective practice and how coaches can engage in it more effectively to enhance experiential learning and subsequently the quality of their practice. He will continue developing a new way of educating BASES trainee practitioners in reflective practice through blended learning (**Cropley, B.** et al. (2018). *Education + Training*, 60, 375-388). **Cropley** is also working with the United States Centre for Coaching Excellence (in collaboration with Dr Kristen Dieffenbach, Executive Director, Centre for Applied Coaching and Sport Sciences, West Virginia University, USA; and Professor Stephen Mellalieu, Network Editor, World Rugby Science Network, Cardiff Metropolitan University) and FAWT to develop approaches to support and enhance the well-being of coaches and support staff. The aim is to demonstrate that by improving the well-being of coaches and support staff, they will be better able to manage their jobs' demands and function more effectively in all areas of their lives. **Cropley's** research will thus seek to drive cultural and organisational change inside and outside of sport and highlight the importance of well-being from both a moral and performance perspective. This approach has been extended into Further Education, working with colleges across Wales to explore the well-being of their learners and staff and how this impacts performance and engagement. This research likely will lead to college-wide interventions and curriculum changes to improve well-being development and support.

M Williams (**Impact Case Study**) will continue with the international collaborative development (HSIRG) and application of a novel, field-based measure of hip, groin and hamstring strength (and more recently anterior cruciate ligament injury). This is in light of the extensive implementation of the specialist 'Nordbord' device by professional and national sports teams, national governing bodies, research centres and clinicians to improve hamstring injury prevention and management. This research will be further synergised through the recent appointment of Dr K Williams (04.01.2021), a graduate Sport Therapist who has over 15 years' experience working in professional and international sport. Both **M Williams** and K Williams will continue their concussion work with the Welsh Rugby Union (Rehabilitation of Prolonged Sports Related Concussion in Sport); a project that includes all professional rugby players in Wales, including senior regional, academy, women's and sevens' squads.

Shearer will extend work with Sport Wales and Swim Wales to further optimise preparation of international athletes, sport psychologists, coaches and support staff for major competitions, including the World Championships, Commonwealth Games and Olympics/Paralympics. He has already expanded this research to examine if and how biofeedback can be used to enhance the physical recovery profiles of elite athletes (2 KESS PhDs with Sport Wales). This is an entirely novel approach to physical recovery that, if successful, will result in an easy, non-invasive and cheap method to enhance recovery. He is also collaborating with Newcastle University to test the same intervention to help elite international swimmers cope with the psychological demands of the pre-competition taper. **Shearer** will continue collaborating with the University of Roehampton to develop research in the area of collective efficacy, imagery and observation. A range of projects are already underway using both eye-gaze and biomechanical modelling to understand action-observation in sport. The aim is to demonstrate the utility of action observation + imagery interventions to enhance individual and team confidence. He has also recently been awarded four years of funding (£186,000) to grow future research that will elucidate how elite performance psychology interventions, combined with adventurous challenges, will improve the mental health of wounded, injured and sick military veterans. This addresses the need to provide a formalised structure to the adventure challenges for veterans that are now popular for improving mental health and well-being. This is the first stage of a project which potentially will be extended further to other populations, including Not in Education, Employment, or Training and those leaving the criminal justice system.

Rainer will form an internal network of researchers across Faculties with the purpose of building on current research outputs that explore the development and impact of fundamental movement skills in children through sport and curriculum-based physical education. This focus will aim to address the growing need to support children to develop the necessary skills and attitudes required for lifelong participation in sport and exercise as well as enhancing children's progression through sport development pathways.

Vascular Health Group: Bailey, Marley, Fall, New, Rose and **Ainslie** are actively developing a Centre fOr Heart and BRain HeAlth (COHBRA). This will be a centre of excellence in basic translational and clinical research, based in the Faculty of Life Sciences and Education. It will also have strategic links to an established collaborative network of internationally renowned researchers. Building on established excellence in heart and brain research under the auspices of the Neurovascular Research Laboratory, COHBRA will offer new expertise in integrative molecular, cardiovascular, respiratory and cerebrovascular physiology, including bespoke nutritional and physical activity countermeasures. The collective focus will centre on generating high impact, fundamental bench science to translational clinical research and population health, utilising expert-led shared core facilities underpinned by state-of-the-art measurement capabilities. By promoting vascular health, COHBRA will develop a collaborative network of community, clinical, academic, industry and public health partners with the collective desire to promote healthy ageing and the corresponding benefits for individuals, their families and society in general.

Bailey and **Rose** will continue to focus on the link between cardiorespiratory fitness (CRF) and postoperative outcomes in patients with cancer and are currently preparing an exercise prehabilitation RCT. It will also focus on patient neuroprotection – as the combination of cancer and impaired CRF compound later life cognitive decline and dementia. This research has outstanding impact potential and current findings are already starting to direct surgical risk stratification, informing patient care and management (see Editorial by Wilson, R.J.T. 2018. *British Journal of Anaesthesia*: 120:1145e1146, doi: 10.1016/j.bja.2018.03.016).

Bailey, Marley, **Fall**, **New** and **Ainslie** will continue to extend their research on the redox regulation of systemic and cerebrovascular function. The research will focus on developing new techniques for the molecular detection and characterisation of biologically relevant free radicals and haemostatic biomarkers implicated in the control of systemic/cerebrovascular function. They will continue to apply these integrated molecular-haemodynamic approaches to novel models to better understand ageing and associated neuroprotective countermeasures. Plans are underway to conduct a first-in-human exercise RCT in patients with dementia.

Bailey and **Marley** will extend their research into the cerebrovascular mechanisms and clinical consequences of prior recurrent concussion, focusing on rugby union and football. **Bailey** recently established new techniques to assess 'individual' components of the neurovascular unit that will provide unique mechanistic insight into brain damage in rugby/football players. This will help inform player management and care and may predict their (potentially accelerated) trajectory towards dementia. Furthermore, **Bailey** and **Shearer** are biomedical scientists for 'Head for Change', a Foundation that promotes a unique 'player-centred' approach to concussion care, support and research. The foundation has recruited many former international-standard rugby union players who have received a clinical diagnosis of early onset dementia and 'probable' chronic traumatic encephalopathy following a history of recurrent concussion. This 'living brain bank' will provide a unique sample of athletes to phenotype and more objective evidence in light of the recent 'Class Action'. Through his research with the European Space Agency (first UK Chair of the Life Sciences Working Group), UK Space Agency and French Government Space Agency, **Bailey** will extend recent novel findings (**Bailey, D.M.**, et al. 2020. *Neuroscience* 441: 142-160) to provide unique mechanistic insight into the neurological complications of deep spaceflight especially when combined with physical exercise 'countermeasures', subsequent to free radical-mediated alterations in brain blood flow. His research has recently been selected for four follow-up parabolic flight campaigns (ground-based spaceflight analogue). This is particularly relevant to 'spaceflight-associated neuro-ocular syndrome', the primary health risk for long-duration spaceflight including a (wo)manned mission to Mars.

2. People

Staffing strategy

The unit's recruitment strategy aims to increase the number of ECRs with exceptional research promise (**Marley**, **T Williams**) and more established independent researchers with recognised international reputations (**Cropley**). This strategy is supported by pathways to develop staff in ways that help them deliver the UoA's objectives to improve outputs, impact and grant capture. It is now mandatory that Research Professors sit on staff interview panels, ensuring research potential including impact is duly considered in new appointments to plan and prepare for the forthcoming REF cycle and further enrich the student experience through research-informed teaching. **Shearer** (**Sports Performance Group**) has also been promoted internally to Professor. This follows **Shearer's** strategic redeployment from USW's Psychology UoA in REF2014 to UoA24 for the current REF cycle, reflecting the focus of his expanding programme of research. **T Williams** is a new appointment (0.7 FTE) to bolster research in the **Sports Performance Group**, while **Ainslie** (0.2 FTE, **Vascular Health Group**) has continued his extensive and longstanding collaboration with **Bailey** that was part of the UoA's REF2014 submission (see prior).

There are also clear strategic reasons for replacing research active staff who leave (**Mullen**). Dr K Williams (1.0 FTE) is a new appointment who specialises in sports rehabilitation and will work closely with **M Williams**. Research staff are also supported by the appointment of 4 x 1.0 FTE Research Assistants. These Research Assistants have and will continue to assist staff with various aspects of the research agenda, including data collection, analysis, and grant preparation. An additional Research Assistant (1.0 FTE) has been funded for three years by the Japan Society for the Promotion of Science. This appointment is part of **Bailey's** Japan Society for the Promotion of Science fellowship, which is aimed at furthering collaboration with world-leading researchers in Japan.

Highlighting the vibrant, supportive and forward-facing environment of SHES, 15 additional staff members who aren't included in this REF submission are actively working towards achieving SRR in readiness for the next REF cycle. Furthermore, no staff are due to retire within the next REF cycle, highlighting the UoA's sustainability. The UoA's academic staff are complemented by formally appointed, clinically qualified Visiting Professors who provide academic expertise and mentoring in bespoke focus areas aligned to the **Vascular Health Group**. For example, senior consultant surgeons, Professors IM Williams, MH Lewis and WG Lewis, and radiologists/anaesthetists, Professors KG Thomas, RG Davies and RM Berg, assist **Bailey** and **Rose** to examine the implications of cardiorespiratory fitness for postoperative outcome in vascular and patients with cancer. Professor J Coulson is a Consultant in Clinical Pharmacology, Toxicology and General Medicine and provides expert input into **Bailey's** team, focusing on the impact of exercise and hypoxia on drug pharmacokinetics-pharmacodynamics. These formal interactions further augment existing collaborations (see below) with some of the most prestigious scientists in related fields of specialist research.

Staff development
All (USW) staff have a formal annual Development Performance Review with their line manager, during which annual performance targets are set in partnership and judged against the previous year's performance. These are reviewed at six-month mid-term intervals. All staff, including those without SRR, are aligned to the Sport, Exercise and Health Cognate Group (CG) led jointly by **Cropley** and **Shearer**. CG activities include face-to-face sessions with staff to develop research projects and support them through the research process, and workshops on research ethics, research process, the nature of applied research, and the generation of research questions. Staff come together at regular networking research mornings to discuss research opportunities and current activities, and to disseminate research findings. This integrated approach encourages the cross-fertilisation of ideas, knowledge and skills. The UoA recognises and USW reward staff for carrying out research and for achieving impact stimulating exchanges between academia and business, industry or public or third sector bodies. It supports and enables staff to achieve impact from their research through CPD, Internal Investment, Academic Progression and Internal Impact Awards. Indeed, an annual Impact Awards conference is held by USW with members (**Bailey**, **Cropley** & **Shearer**) and PGRs aligned to the UoA consistently winning awards for their research. Furthermore, the UoA conforms to the requirements of the Concordat to Support the Career Development of Researchers and has its own bespoke mentoring strategy, as follows:

- Senior researchers (including Visiting Professors and international collaborators) provide mentorship and guidance to help develop research.
- Formal interactions are fostered through a seminar series and subtheme meetings to discuss research proposals, outputs, grant activity and impact.
- Staff with significant responsibility for research (SRR) have time to conduct their work (>20% of formal workload protected).
- Enhanced research time is funded by the Faculty via competitive Fellowships for ECRs (40% of formal workload protected) and more senior researchers (70% of formal workload protected). This is managed through Faculty senior management. **M Williams** (**Impact**

Case Study) secured one of the senior Fellowships, that was instrumental in supporting him to be returned in the current cycle and further develop his impact profile.
- Funding provided for staff and PGRs to attend international conferences.
- Central university services, as detailed in REF5a, further support researchers through training, assistance writing grant bids, providing information on funding opportunities, and help integrating impact into all aspects of the research process, from project genesis to dissemination and achieving impact.

Post-Graduate Researchers (PGRs)
Following REF2014, the UoA was recognised by the university as one of its leading research groups. Significant investment was made via 7 fully funded PhD studentships early in the current REF cycle. The group has since supervised 10 PhDs (no research-based professional doctorates) with 50% completing on time (Table A). This is consistent with the USW Research Strategy (2018-2028) with 6 more soon to complete early in 2021. The recruitment of exceptional PGRs from the UK and around the world is central to the UoA's research philosophy. Students are active across the research subgroups and are funded from a range of sources, including industry, charity, sport and Welsh, UK and EU government.

Table A. Doctoral Completions

Date period	Number of Doctoral Degrees
01-08-2013 to 31-07-2014	3
01-08-2014 to 31-07-2015	0
01-08-2015 to 31-07-2016	1
01-08-2016 to 31-07-2017	3
01-08-2017 to 31-07-2018	1
01-08-2018 to 31-07-2019	0
01-08-2019 to 31-07-2020	2
Total	**10**

UoA research students have open-plan office space at the USW Sports Park II complex and on Glyntaff Campus, where the UoA's health and exercise science laboratories are located. All SHES students are also encouraged to present their work at national and international conferences. Students present annually at The Physiological Society Meeting, BASES Annual Conference and the Pan-Wales Student Research Conference. SHES PGRs are managed locally at Faculty level, with a focus on improving the student experience. The Faculty has achieved consistently high student ratings for the research environment. PGRs are encouraged to attend a variety of regular faculty events, such as the Annual Research Student Presentation Day, the (former) 'Tea at 3' Faculty seminars and research group meetings. The UoA actively promotes engagement with its research students and offers bespoke training sessions based on their expressed needs.

The Faculty has a Research Student Coordinator who is responsible for quality assurance and the research student experience and acts as an independent point of contact for students and the supervision team. PGR representatives engage with the wider PGR community to provide a student voice. The open agenda at the Faculty Research Degrees Committee (**Cropley** & **Shearer** are members) provides a formal mechanism for students to discuss issues. Student representatives have set up a Facebook page for PGRs and hold regular coffee mornings funded by the Faculty. In addition to formal training for supervisors, the Faculty provides well-attended supervisor surgeries at each campus, during which supervisory teams can be updated on regulations and discuss any challenges and areas of good supervisory practice.

Equality and diversity (E&D)
The UoA is committed to the University's Strategic E&D Plan, as outlined in REF5a, and inclusivity is at the core of its work. Members of the unit are active in a number of the

University's formal E&D structures. USW has been awarded an Athena SWAN bronze award for gender equality, diversity and inclusivity. Women are often underrepresented in Higher Education, particularly in Science, Technology, Engineering, and Mathematics (STEM) and we acknowledge that this is indeed the case in our UoA. However, we are actively engaged in addressing this gender imbalance as part of future plans (e.g. future launch of a USW Women in STEM Network to complement the Wales Women in STEM Network originally founded by USW in 2019). At Unit level, we are looking to recruit and retain upon graduation, more female PGRs (4 current) and FT members of staff (e.g. Dr K Williams) into the unit while also focusing on the development of current staff who are actively researching women's participation in sport, so that they can achieve SRR. Colleagues taking maternity/paternity or adoption leave are fully covered, including an overlap period pre- and post-leave to ease the transition. Senior managers also allocate and monitor workload and ensure that members' research time is protected. Workload is individually adjusted for staff facing periods of acute pressure or personal distress, and additional research support is offered where possible.

3. Income, infrastructure and facilities

Income

UoA research activity over the REF 2021 period has been facilitated by a clear increase in external funding compared with the previous REF cycle (Table B). The **Sports Performance group** (**Cropley** & **Shearer**) has sourced funding from diverse sources, including KESS in conjunction with industry partners (Swansea City F.C., The Football Association of Wales Trust and Sport Wales (European Social Fund)), professional bodies for sport (e.g. BASES), and government agencies (Sport Wales and Academic Expertise for Business). The **Vascular Health Group** has also secured grants from diverse sources, including the NHS (Cwm Taf Health Board); charitable foundations (Research into Ageing, The Royal Society, JPR Williams Foundation, Canadian Stroke Consortium/Heart & Stroke Foundation, Heart and Stroke Foundation Canadian Partnership for Stroke Recovery (CPSR) and Réseau Provincial De Recherche En Adaptation-Réadaptation (REPAR)); Welsh Government; industry (AstraZeneca Pharmaceuticals, ADInstruments), and international organisations via prestigious, fully-funded fellowships for **Bailey** (University of Otago New Zealand, Toyo University Japan and University of British Columbia, Canada).

Table B. Income

Date period	Income (£)
01-08-2013 to 31-07-2014	630
01-08-2014 to 31-07-2015	34,463
01-08-2015 to 31-07-2016	13,819
01-08-2016 to 31-07-2017	22,694
01-08-2017 to 31-07-2018	56,543
01-08-2018 to 31-07-2019	42,368
01-08-2019 to 31-07-2020	33,228
Total	**203,745**

Infrastructure and facilities

Research infrastructure and facilities have been strategically enhanced since 2014 and supported by strategic research infrastructure funds underpinned by a collective focus on research impact activities. The £16 m Sport Park II facility was built as part of the University's investment in sport, health and exercise sciences. Sport Park II is a 10,150 m² new-build teaching and research facility focused on Sports Performance. The building includes space for PGRs and applied research facilities. It also contains one of the only full-sized indoor football pitches in the UK. This supports CFRW activities by offering a unique opportunity to conduct applied research in context-specific settings. It also allows the UoA to form future collaborations with the FAW medical team, that also hosts a FIFA-endorsed medical centre. Sport Park II complements the laboratory space available to UoA students on the University's

Glyntaff campus and further enhances interaction between the **Sports Performance Group** and the **Vascular Health Group**. The UoA's infrastructure plan for 2021-2026 includes the construction of Sport Park III. This further new build would accommodate all laboratory facilities, locating all of the UoA's teaching and research on a single campus. To date, over £9 m of capital bid funding has been secured to support this exciting initiative.

The **Sports Performance Group's** specialist, field-based equipment is based at Sports Park II, including a 3DCODA motion analysis system and ASL mobile-eye tracker. Vald Performance has donated approximately £100,000 of equipment (Nordbord, Groinbar, Humantrak and Catapult Clearsky) and licences to **M Williams** for research use during the current REF period. The Sports Park II development included investment in a world-class, dual-purpose teaching and research strength and conditioning room. **Shearer** has access to specialist biofeedback, EEG, CANTAB cognitive test battery and eye-tracker equipment in conjunction with extensive infrastructure (data collection laboratories) under the auspices of the School of Psychology.

The **Vascular Health Group's** Neurovascular Research Laboratory is based in the Alfred Russel Wallace Building. As well as the 'standard' infrastructure of a well-equipped biochemistry/physiology/exercise science laboratory, specialist facilities include a BASES-accredited exercise physiology lab and an environmental chamber that is temperature, humidity and oxygen controlled. It also facilitates state-of-the-art analytical techniques including: X-band electron paramagnetic resonance spectroscopy and ozone-based chemiluminescence (for the detection and molecular characterisation of free radicals); multi-channel near infra-red spectroscopy (to assess regional flow and tissue oxygenation); trans-cranial Doppler and Duplex ultrasonography (to measure blood flow); and breath-by-breath respiratory gas analysers (to measure oxygen uptake). The UoA also has on-site access to UV spectroscopy, ELISA and RT-PCR given extensive collaborations with colleagues in chemistry and biology at USW and additional access to a world-class core facility for nuclear magnetic resonance and electron nuclear double resonance spectroscopy, c/o a collaboration between **Bailey** and Cardiff University School of Chemistry (Prof. D Murphy).

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

Collaborations, networks and partnerships that develop impact

The **Sports Performance Group** has established comprehensive collaborations with national governing bodies, such as FAWT, through the CFRW and Sport Wales (**Cropley**). **Cropley** is also working with Cardiff Metropolitan University, University of Portsmouth, St. Mary's University, Liverpool John Moores University, Edge Hill University, Brunel University, Curtin University (Australia), West Virginia University (USA), and University of Wisconsin, La Crosse (USA). He also has research links with the International Society of Sport Psychology, contributing to its codes of ethics for applied practice, and with UK Coaching, which informs Government of policy related to sport coaching in order to impact positively on society. **Shearer** conducts research with collaborative partners at Swansea University, University of Roehampton, Leeds Trinity, University of North Dakota (USA), University of New England (USA), and the University of Sydney (Australia). **Mullen** continues with his research with the FA and has developed extensive collaborations with colleagues at Bangor University and Cardiff Metropolitan University. **M Williams** collaborates with colleagues at the University of Queensland (Australia), Griffith University (Australia) and the Australian Catholic University at Melbourne. His research on hamstring injury has directly impacted injury prevention and management in a wide variety of professional sports, including:

- Football: 20 English Premier League teams, 72 other UEFA teams, 11 Major League Soccer teams.
- Basketball: 22 NBA teams.
- American Football: 21 NFL teams; 53 US NCAA organisations.

- Rugby: 30 professional Rugby Union and League teams.
- Baseball: 15 US Major League teams.
- Australian Rules Football: 17 Australian teams.
- Other organisations including 54 health clinics, 37 National Governing Bodies, 22 Research institutes, and 38 Performance Centres (see www.valdperformance.com – Who's on BORD).

The **Vascular Health Group** have established an impressive international network of published collaborations with world-leading specialists in the following areas of research:

- Space medicine*:* Normandie University, France; European Space Agency; French Space Agency.
- Free radicals, inflammation and haemostasis*:* University of Marseilles, France; University of Colorado Denver, USA; University of Copenhagen, Denmark.
- Systemic vascular function*:* University Hospital Lausanne, Switzerland; University of Utah, USA.
- Brain structure and function*:* Yale University School of Medicine, USA; Case Western Reserve University, USA; University of Montpellier, France; University of North Texas Health Science Center, USA; University of Istanbul, Turkey; University of Split, Croatia; Boston University, USA.

Members have also established numerous international collaborations (including in Denmark, Canada, USA and France) with world-leading specialists to explore the neuroprotective bases of physical activity. Consequently, **Bailey** has developed a network of 9 Visiting Professors, who collaborate with the **Vascular Health Group**. **Bailey** was also appointed the Reichwald Family Chair of Preventative Medicine at the University of British Columbia (Canada), and is a Visiting Professor at the University of Ulster, Swansea University, Cardiff University and Aix-Marseille University (France).

Wider activities and contributions to research, economy and society
Collectively, members of the UoA make a major contribution to the discipline. The collaborations noted above and the extent of the UoA's contributions are a strength of this submission and add value to the research culture.

Editorial activities

1. **General/Managing Editors**: *Experimental Physiology, Scandinavian Journal of Medicine and Science in Sports, Frontiers in Physiology: Clinical and Translational Physiology* (**Bailey**); *International Sports Studies* (**M Williams**).
2. **Special Issue Section Editors**: *Journal of Applied Sport Psychology* (**Cropley**).
3. **Editorial/Review Board Members**: *Journal of Applied Physiology, Oxidative Medicine and Cellular Longevity, Dataset Papers in Medicine (Vascular Medicine Section), Applied Physiology, International Journal of Vascular Medicine, Antioxidants, Extreme Physiology and Medicine* (**Bailey**); *The Sport Psychologist, Case Studies in Sport and Exercise Psychology* (**Cropley**); *Frontiers-Movement Science* and *Sport* Psychology (**Shearer**).
4. **Reviewers**: Members of the unit have contributed to peer review activities across a total of 36 journals.
5. UoA staff also undertake peer and expert review for funding agencies, research councils and other organisations including: NASA, European Space Agency, French Spacer Agency, Biotechnology and Biological Sciences Research Council, Medical Research Council, and Wellcome Trust (**Bailey**); Economic and Social Research Council, The Leverhulme Trust and British Academy (**Mullen**).

Unit members have had a central influence on the strategic direction of professional organisations/subject associations and have fulfilled key professional service roles. **Mullen** was the Chair of the British Psychological Society Division of Sport and Exercise Psychology. **Cropley** contributes significantly to the professional development programme for BASES and

has been awarded Fellow status of the organisation in recognition of his ongoing work. **Cropley** has been instrumental in developing and delivering the coach education programmes of the FAWT, which are recognised and accredited by the Union of European Football Associations through CFRW. **Shearer** and **Cropley** are key members of the WIPS Research Steering Group (sport psychology and coaching science, respectively) responsible for ensuring that the research conducted has direct translational impact into elite sport. **Rainer** is a panel member of the Wales Sport and Academia Network hosted by Sport Wales with the aim of improving the translational impact of research conducted in Welsh Universities for sport in Wales at all levels. **Bailey** was the Chair of the GB Elite Performance Working Group for the 2016 Olympic Games. He is currently Cardiovascular Physiology Lead to the Cardiovascular Research Group Cymru (Welsh Assembly Government; 2010-present); Stroke Steering Group Member to the Older People Aging Research network (2012-present); member of the Working Group on Atherosclerosis and Vascular Biology for the European Society of Cardiology; Advisory Member of the National Cardiovascular Network for Wales; the first UK Chair of the internationally prestigious Life Sciences Working Group c/o European Space Agency, leading Europe's best scientists to guide and inform future space-related biomedical research with the long-term focus on deep spaceflight; Member of the Space Exploration Advisory Committee c/o UK Space Agency. **Bailey** interacts regularly with the Welsh Government and recently presented to the Welsh Government at the Senedd highlighting the neuroprotective benefits of physical activity as part of the 'Sport & Exercise Science Education: Impact on the UK Economy' policy document published under the auspices of The Physiological Society.

Cropley, Mullen, Shearer and **Bailey** hold or have completed individual consultancies with industry, including the English Rifle Shooting Association, Brighton and Hove Albion F.C., Swansea City F.C., Cardiff Blues R.F.C., Team Bath Super League Netball, the Welsh Rugby Union, the Football Association of Wales, The Football Association, Sport Wales, UK Sport, UK Coaching, BASES and England Golf. They also provide veterans support for adventurous challenges with 65 Degrees North and Leadership Challenges. **Bailey** is the holder of a prestigious Royal Society Wolfson Research Fellowship (2017-2022), the first to be awarded to an academic in the heath and exercise sciences field in the UK. He is also a Fellow of The Physiological Society, Royal Society of Chemistry, American College of Sports Medicine and Pulmonary Vascular Research Institute. **Bailey** has also been acknowledged by ADInstruments as a 'Science Hero' and received prestigious funded/competitive research fellowships including: William Evans Fellowship from the University of Otago, New Zealand (2014); International Research Fellowship by the Japan Society for the Promotion of Science, Toyo University, Japan (2019); International Exchanges Award by the Royal Society, Yale University, USA for research on the integrated regulation of cerebral blood flow to the mammalian brain. **Bailey** works extensively with the media to further extend the reach and significance of the UoA's research including science documentaries with BBC One (including Horizon), ITV, Channel 4, Channel 5 and Al Jazeera. His research has helped inform the recent 'Class Action' against World Rugby Union. **Cropley** and **Shearer** have also appeared on ITV Wales and BBC Sport. UoA members have also conducted multiple national and international PhD/MD examinations and other academic activities in the UK, France, Spain, USA, Canada, Japan and New Zealand.