Institution: University of Portsmouth

Unit of Assessment: 24 Sport and Exercise Sciences, Leisure and Tourism

1 Unit context and structure, research and impact strategy

1.1 Unit Context

All staff submitted to Unit of Assessment (UoA) 24 are from the School of Sport, Health and Exercise Science (SHES). Previously known as the Department of Sport and Exercise Science, this title represents a change from REF 2014 and reflects our significant expansion in the focus and volume of our health-related research, in accordance with our strategic priorities (see Section 1.3). SHES celebrated its 25th anniversary in 2020, with *Thelwell* as Head of School since 2009. The School consists of 33 academic staff (14 female (F): 19 male (M)) and three Senior Research/Research Associates (3F: 0M), of which 21 (9F: 12M, 20.5 FTE) are returned, a 163% increase relative to REF 2014 (4F: 4M, 7.5 FTE). This is our second submission to the 'Sport and Exercise Sciences, Leisure and Tourism' UoA, prior to which staff were submitted to the RAE 2008 in the area of 'Allied Health Professions and Studies'. We were commended in REF 2014 for the vitality and sustainability of our research environment in focussed '*niche areas*' and our '*impact strategy based on unique research*' was noted as '*a particular strength*'; these remain hallmarks of our Unit.

1.2 Unit Structure

Our Associate Head Research (*Corbett*) provides research and impact leadership, assisted by three Thematic Research Group (TRG) leads, who enable our research by providing operational leadership, strategic input and a supportive framework across three multi-disciplinary research groups (Table 1). Our TRGs reflect the historical niche expertise of the School (environmental ergonomics, occupational physiology, breast health), as well as areas where we have made targeted investment and grown our critical mass and capabilities over the census period.

Our TRGs are:

- **Extreme Environments (EE):** with a world-leading reputation, developed over a 22-year period, EE's research examines the physiology, pathophysiology, psychology and psychophysiology of extreme terrestrial and aquatic environments, and the selection, preparation and protection of individuals required to operate in these environments. Established partnerships with key stakeholders include the Royal National Lifeboat Institution (RNLI) in water safety, UK Armed Forces in defence, and the English Institute of Sport (EIS) in elite sport. These partnerships deliver a sustained impact portfolio with national and international reach and significance, as described in our Impact Case Studies (ICS) *UoP24ATHLETES, UoP24WORKERS* and *UoP24WATER*.

- **Physical Activity, Health and Rehabilitation (PAHR):** developed from the Breast Health Research Group established in 2005, PAHR reflects a marked increase in size and scope (see Section 2.1) resulting from our strategic investments and partnership development (see

Section 1.3). PAHR's research employs exercise and other non-pharmacological approaches to enhance the understanding and management of a range of chronic disease conditions. PAHR also examines barriers to exercise and approaches to overcoming them, including rehabilitation from conditions preventing physical activity. They work with a range of industry partners, who support their work in breast health, as well as health groups (e.g. the NHS) and charities (e.g. the Cystic Fibrosis Trust), where their research is changing practice and informing clinical exercise testing guidelines.

- **Individual, Organisational and Occupational Performance (IOOP):** integrates physiological, psychological and biomechanical aspects of human performance. IOOP has evolved from the Human Performance Research Group submitted in REF 2014, expanding its focus to encompass organisational and occupational performance contexts. The group has fostered links to a range of elite sports organisations (e.g. Professional Game Match Officials Limited), governing bodies (e.g. UEFA) and occupational groups (e.g. Energy Institute), where their research has increased understanding of job-related physical demands and informs the policies and practices of a range of occupational groups undertaking arduous, physically demanding roles, as described in *UoP24WORKERS*.

Table 1: Thematic Research Groups, composition and structure (***group lead***; *early career researcher*).

Extreme Environments	Physical Activity, Health and Rehabilitation	Individual, Organisational and Occupational Performance
Costello	***Saynor***	***Wagstaff*** *(Reader)*
Tipton (Professor)	*Wakefield-Scurr (Professor)*	*Thelwell (Professor)*
Corbett	*Burbage*	*Brown*
Eglin	*Exell*	*Dicks*
Lomax	*Gorczynski*	*Milligan*
Massey	*Mills*	*Stebbings*
	Perissiou	*Webb*
	Shepherd	

Compared with traditional discipline-based research groups, our thematic approach facilitates inter- and multi-disciplinary research approaches, whilst our distinctive expertise in clearly defined areas underpins numerous long-standing, high-value partnerships that facilitate stakeholder input to the research process. This collaborative strategy enables us to meet our key partners' varied needs across sport, health, defence and industry, and has clearly defined impact pathways. Our thematic research and impact approach aligns with University-wide research themes in 'Health and Wellbeing', 'Democratic Citizenship' and 'Sustainability and the Environment' (REF5a, p.9), and is enhanced by their support (see Section 2.2 and REF5a, p.20).

1.3 Achievement of strategic aims for Research and Impact

Our strategic research and impact aims for REF 2014 were:

i) *To increase research-active staff by one person per annum in areas aligned with our research themes and expand research activity within existing research groups.*

We have grown our headcount from REF 2014 by 163%, through mentoring, to develop the research profile of extant staff (n=5, 2F: 3M), and by recruiting new staff with strategically relevant research expertise (n=8, 3F: 5M). As a result, we have developed a focussed critical mass around each TRG. EE has increased from three to six staff (3F: 3M), and includes nine postgraduate research students (PGRS) and one Professional Doctorate (Prof Doc) student. PAHR has grown from two to eight staff (4F: 4M), and includes six PGRS and three Senior Research/Research Associates (3F: 0M). IOOP has increased from three to seven staff (2F: 5M), and includes twelve PGRS and ten Prof Docs – the latter reflecting the group's emergent organisational and occupational focus.

This growth in research-active staff has increased our expertise, techniques and methodologies and has positively affected the Unit's overall research activity, quality and vitality. This is evidenced by notable increases since REF 2014 in a range of indices of research activity and quality, including total number of outputs produced (+274%, from 112 to 419), outputs published in top-quartile journals (+400%, from 51 to 255), and outputs with international collaborators (+431%, from 29 to 154).

ii) *Consider new within- and across-group occupational and health-related research areas aligned to national and international research challenges.*

All three TRGs have made significant contributions to important occupational and health-related research challenges. For example, the application of our environmental physiology expertise to a variety of new health-related research challenges has stimulated a novel research strand, which spans PAHR and EE, and is examining the therapeutic role of environmental stressors in clinical conditions, such as type 2 diabetes mellitus (*Shepherd*, PAHR; *Corbett,* EE, in *Journal of Applied Physiology*). PAHR has also applied EE's techniques for assessing cold injuries to examine the efficacy of nutritional interventions on vascular control in individuals with cold sensitivity and Raynaud's phenomenon (*Shepherd*, PAHR; *Eglin*, EE, in *Nitric Oxide* and *Journal of Applied Physiology*). Our cross-group interdisciplinary research has provided new insights into the role of psychophysiological factors in the development of heat illness, a potentially fatal condition affecting ~100 UK military personnel per annum (*Corbett,* EE; *Wagstaff*, IOOP, in *Sports Medicine*). Similarly, IOOP has integrated biomechanical and physiological research approaches to better understand the relationship between technical proficiency and the physical requirements of arduous occupations, including ladder-climbing by technicians servicing wind-turbines for the offshore energy industry (*Milligan*, in *Applied Ergonomics*). Together, this research addresses key national and international challenges, developing a workforce serving the emerging needs of the renewable energy industry, protecting workers exposed to arduous conditions, improving the quality of life for individuals with chronic disease, and developing new, low-cost, non-pharmacological clinical therapies.

iii) *Increase the volume and diversity of external research and knowledge exchange income.*

Since REF 2014, we have increased the number of staff securing externally-funded research income as Principal Investigator (PI) by 350% (from 4 to 18). Furthermore, 100% (21 of 21) of our Unit now contribute to research income as either a PI or Co-Investigator, compared to 63% (5 of 8) in REF 2014, indicating a culture-shift consistent with a vital research environment. Our broadened income base has generated a 140% increase in research income (from £1,008,587 to £2,416,079) whilst our knowledge exchange income has also grown 242% (from £262,102 to £897,033) and further enhances our Unit's sustainability.

Our increased funding diversity is evidenced by an 83% increase in the number of individual funders of our research (from 23 to 42, see Section 3.1). Funding now spans smaller-scale individual projects to joint funding bids, multi-partner projects, and participation in complex, consortium-based international research programmes, e.g. the Arctic and North Atlantic Security and Emergency Preparedness Network, supported by EU Horizon 2020 funding. Collaborative partnerships and strong stakeholder involvement remain hallmarks of our work. A key strategy in broadening our funding base was to grow our health-related research through increasing collaboration with regional NHS Trusts (see Section 3.1). We are now undertaking collaborative research with the Portsmouth Hospitals University NHS Trust (PHUT) respiratory, rheumatology, diabetes and endocrinology, colorectal surgery, and renal units and with the wider Wessex Kidney Centre, and working with groups within the University Hospital Southampton NHS Foundation Trust, and the NIHR Applied Research Collaboration (ARC) Wessex.

iv) *Continue to develop the research culture and environment.*

The critical mass developed around a common theme within each TRG fosters a shared research identity and reputation, engenders a facilitative culture supporting integrity and openness, and enables a focussed and coordinated approach to training and developmental activities (see Section 2.2). Our TRGs include affiliate membership from key non-academic partners, as well as visiting academic staff. This enriches our culture by providing real-world context and understanding of end-user requirements, as well as research perspectives from other academic institutions. At the University level, we comply with the Concordat to Support Research Integrity and the UK Research Integrity Office Code of Practice for Research (REF5a, p.22). At the Unit level, in addition to utilising appropriate ethical review boards for all of our research (e.g. Institutional, MoDREC, Health Research Authority), we also employ our own Independent Medical Officer to advise on safety for human research. Our commitment to 'open-access' is supported by 242 of 244 (99.2%) outputs being made open-access since 01.04.16, including 100% of our submitted outputs. All of our Unit are ORCID registered, we utilise clinical trials registration databases where appropriate, and make our data sets openly accessible through the University repository.

To support the strategic ambitions of our TRGs, we have also made considerable investment in developing our physical research environment, including upgrading EE's laboratory infrastructure, developing a cardiovascular laboratory and off-site clinical testing space for PAHR, and expanding IOOP's capability for occupational simulation and field-testing (see Section 3.3). The effectiveness of this approach is evidenced by a range of indices of vitality in our research culture and environment: research-active staff numbers have increased by 163%, output volume by 274%, output quality by 400% (as measured by publications in top-quartile

journals), staff generating external research income by 350%, total research income by 140%, and PGRS completions by 100%. Additionally, 95% of staff now supervise PGRS (our newest staff member is the only exception) and PGRS and Prof Doc registrations are 138% higher than in REF 2014 (increasing from 16 to 38).

v) *Capitalise on and strengthen existing collaborations which underpin policy, practice, and product development and improve human health, safety and performance.*

Our strategy for enabling impact is underpinned by the development of sustained, high-value, collaborative relationships with key stakeholder groups in areas aligned to our unique research expertise. For example, our research examining the psychophysiological responses to cold-water immersion continues a 21-year relationship with the RNLI and underpins their 'Respect the Water' campaign, which was launched in 2014 and has since changed water safety behaviour and saved lives. Similarly, our collaborations with EIS/UK Sport extend over four Olympiads. This relationship has improved athlete safety, welfare and performance in hot environments, changed support practices across multiple Olympic sports, informed athlete selection policies and contributed to Olympic medal success during this REF period. Our Defence research has grown from long-established military links (*Tipton*, *Milligan* and *Massey* were formerly defence scientists), and is enabled by the unique networks, expertise and understanding we have cultivated with these groups over many years. Since 2014, our Unit has improved the diagnosis and treatment of non-freezing cold injury, increased test sensitivity in the Institute of Naval Medicine's Heat Illness Clinic and informed body-armour design for improving infantry protection. The enduring nature of these relationships demonstrates our sustainability and the effectiveness of our 'collaborative' strategy is further evidenced in our ICS *UoP24ATHLETES*, *UoP24WORKERS* and *UoP24WATER*. Moreover, we have capitalised on these collaborations by supporting individuals within the Unit to lead funded research with these groups for the first time (*Corbett*, *Lomax*, *Wagstaff*, see Section 3.1), thereby broadening our future impact base and ensuring these relationships endure.

vi) *Increase participation in regional, national and international knowledge exchange forums and host events for key stakeholders that link with our research themes.*

During this REF period, EE and IOOP have hosted three major international conferences: the 16th International Conference on Environmental Ergonomics, the 3rd International Conference on Physical Employment Standards, and the Physiological Society's 'Extreme Physiology: Life at the Limits' meeting. PAHR (*Burbage* and *Wakefield-Scurr*) ran bi-annual workshops on 'The science behind breasts and bras', disseminating their research to 137 international industry stakeholders; this pump-priming activity has generated more than £25k of knowledge exchange income since 2014. We have also established two international knowledge-exchange forums. In 2014, *Tipton* (EE) co-founded the International Drowning Research Alliance (http://idra.world/), a global scientific network linking researchers and those involved in the management and prevention of drowning. In 2016, *Webb* (IOOP) founded the Referee and Match Official Network, an international network of scholars and policy makers with interest in the management, leadership and operational environment of match officials. Through these forums, we have developed a new, systematic, model of the drowning process, which has provided a framework for research examining the drowning process (in *American Journal of Emergency Medicine*), and

highlighted the issue of umpire abuse (in *Managing Sport and Leisure*), providing the evidence base for international rule changes governing player conduct within cricket (MCC Law 42).

At the national and regional level, EE has run workshops on 'Performing in extreme environments' for organisations including the EIS, British Olympic and Paralympic Associations, British Triathlon, British Sailing, British Swimming and UK Athletics. By engaging practitioners from relevant stakeholder-groups, we have also developed clear impact pathways. These are detailed in our ICS describing how our research has changed practice and policy, and improved safety and performance, for Athletes performing in 'Extreme Environments' (*UoP24ATHLETES*). We also hosted the 2018 'Science of Flood Rescue' meeting, facilitating the dissemination of our work to key stakeholders and resulting in the UK Department for Environment, Food and Rural Affairs (DEFRA) incorporating our research into their Flood Rescue Concept of Operations (*UoP24WORKERS*).

1.4 Future strategic Research and Impact aims

SHES 'Vision 2030' for Research and Impact is to '*use our areas of internationally excellent research to develop and share new knowledge and to inspire and positively impact society*.' Our future strategic aims for Research and Impact are aligned to this vision and build upon the '*realistic future strategy*' that was praised by the REF 2014 subpanel, whilst also reflecting our Unit's considerable progress. We will continue to focus our resources on our TRGs, where we have established a unique expertise with an international research reputation, or where this is on a developing trajectory. We will grow our capabilities around our clearly defined, multi-disciplinary thematic research areas and apply our distinctive expertise to provide unique approaches to addressing societal challenges.

Specifically, we will:

i) **Broaden the research base underpinning our areas of thematic excellence and increase research leadership**. We will optimise our staffing resource by increasing the proportion of our academic staff making a significant research contribution within our TRGs, i.e. research intensity (currently 60% of 'eligible' FTE count). Having increased our proportion of mid-career researchers since 2014 (see Section 2.3) we will balance increased intensity by supporting and developing more of them into recognised research leaders (Readers and Professors). Together, these strategies will ensure our vitality, sustainability and continued excellence in our thematic research areas. *Targets:* 75% research intensity; 50% growth in research leaders.

ii) **Expand the application of our established research excellence to address new societal issues**. Our TRGs will apply their unique multi-disciplinary expertise, specialist facilities, and infrastructure to new research challenges where we have yet to fully apply and exploit our capabilities. These will align with University-level research themes e.g. 'Health and Wellbeing', 'Sustainability and the Environment' (REF5a, p.9). We will address critical societal challenges such as the effects of climate change on the work force and on clinical cohorts, as well as the occupational challenges of an ageing work force with increased comorbidities, and health-related challenges from the Covid-19 pandemic. *Target:* develop at least one new multi-disciplinary research strand.

iii) **Nurture established impact pathways and cultivate new ones to support our emergent health-related research**. We will host and participate in relevant knowledge-exchange forums and further develop patient and public involvement in our health-related research. This will ensure that we deliver the greatest positive societal impact from our research and realise the translational benefits of our investment in expanding our health-related research. *Target:* all TRGs to contribute to REF 2028 ICS portfolio.

iv) **Grow our PGRS cohort**. Our established and effective processes for developing and supporting our PGRS mean that our Unit is positioned to further grow PGRS numbers, whilst retaining high satisfaction (see Section 2.3). We will particularly target growth in Prof Doc candidates recruited from relevant stakeholder groups, facilitating impact generation from our PGRS cohort, sustaining partnerships, and contributing to our ongoing vitality. *Target:* 50% growth in PGRS completions.

v) **Maintain integrity and transparency at the heart of our research and impact activities**. We will continue to adhere to the highest ethical standards and operate according to best-practice (e.g. NIHR Good Clinical Practice). In addition, we will: (i) register our research on relevant databases (e.g. clinical trials registration, PROSPERO); (ii) adhere to appropriate reporting guidelines (e.g. CONSORT and PRISMA); (iii) be transparent in researcher contributions (e.g. CRediT); and, (iv) continue making our research publicly available to facilitate maximum societal benefits. *Target:* >95% open access outputs and data.

2 People

2.1 Staffing strategy

We have retained and returned all staff from our REF 2014 submission. New appointments during this REF period make up 38% of staff in our Unit (3F: 5M). We recruited all staff in accordance with Institutional polices for minimising unconscious recruitment bias (REF5a, p.30). Our strategy for new appointments reflects our ability to attract researchers with the relevant expertise, techniques and skillset to enhance capacity and capability around each TRG, and evidences our strategic approach to investment to deliver our research ambitions.

In line with our strategic aim to grow our inter-disciplinary health-related research capability, the majority (5) of our new appointments have been within PAHR. *Saynor*, *Shepherd* and *Perissiou* are exercise physiologists whose expertise covers a range of chronic conditions; they have increased our Unit's capabilities in conducting clinical trials, macro and microvascular assessment, and clinical cardio-pulmonary exercise testing. *Gorczynski*, a chartered psychologist with expertise covering a range of mental health conditions, investigates individual and environmental interventions to prevent and manage chronic diseases and expands our health-related psychology capability. *Exell*, a biomechanist with expertise in the assessment of biomechanical asymmetry and strength imbalance, increases our clinical rehabilitation research capability. New appointments within our other TRGs have consolidated and enhanced areas of existing strength. *Costello*'s research in cognition in extreme environments has expanded the psycho-physiological capability of EE. *Brown*, a chartered psychologist with expertise in thriving and well-being, and *Stebbings*, whose work examines the benefits of community-based sport

and physical activity for marginalised and disadvantaged populations, have added new expertise and capability within IOOP.

We have also employed a new Independent Medical Officer to oversee medical aspects of our research and utilised visiting (n=4) and honorary (n=4) research staff to support our TRGs. These appointments enrich our research culture and expand the Unit's senior research expertise by providing research mentoring for our early- and mid-career academic staff, aiding in the training, supervision and development of our PGRS, and contributing to funding applications, income generation and networking opportunities. For example, [text removed for publication], accessing relevant populations, and training the associated PGRS.

Our future staffing strategy will remain focused on the needs of our TRGs, guided by their requirements to fulfil our strategic ambitions for research and impact. We will ensure that we maintain the critical mass that we have established, with any new appointments informed by the expertise, skillsets and techniques required to enhance our group's capabilities, and continue our strategic use of visiting and honorary appointments to extend our collaborative research networks.

2.2 Staff development

Our staff development strategy aims to grow the capability, profile and collaborative networks of our researchers, using a combination of in-school training and support systems, wider University-level initiatives (REF5a, pp.33-37), and relevant external initiatives such as those offered by the NIHR (e.g. the Grant Applications Masterclass and Good Clinical Practice training). We identify and review our staff's development needs annually through the Performance and Development Review (PDR) process (REF5a, p.53), which also facilitates the linkage between individual and Unit-wide research objectives.

All new staff are allocated an experienced mentor, receive 0.2 FTE protected research time for 1 year, and are eligible for 'start-up funds' (up to £5,000) to pump-prime their research. We further assist our Early Career Researchers (ECRs) through an additional 0.1 FTE protected workload (2 years) and preferential PGRS funding, whereby internally funded studentships are only available to supervisory teams whose first supervisor is an ECR, with additional supervisors providing mentorship. Through this process we awarded *Saynor* (ECR at appointment) and *Brown* fully-funded PhD studentships to support their research programme development, and new staff members *Costello*, *Gorczynski*, *Shepherd* and *Exell* tuition-fee funded PhD studentships. Together, this support has enabled *Brown* (Olympic Studies Centre), *Perissiou* and *Costello* (both Physiological Society) to win competitive early career funding, and *Exell* to obtain International Research Exchange funding (Royal Society). We also support new staff via institutional researcher development funding (REF5a, p.41). For example, *Saynor* received £13,000 to develop international research links and collaborations with local NHS trusts. Consequently, she was invited to deliver two international keynotes and, in combination with the aforementioned start-up funding and PGRS support, secured early career funding from the Cystic Fibrosis Trust, and subsequently captured larger grants (e.g. £94,000 from the PHUT) and external PGRS funding.

Our Unit demographics have evolved considerably since REF 2014; we now have a lower proportion of ECRs (from 38% to 19%) and a higher proportion of mid-career staff (from 38% to

62%). Therefore, our support and development mechanisms for mid-career staff are crucial for achieving our future strategic aims to increase research intensity and grow our researcher leadership. Our primary support mechanisms for mid-career staff operate through our TRGs and include mentorship from senior (Professorial and Reader), honorary and visiting staff members, and supportive access and engagement with key collaborators and partners via each group's extended networks. In addition, our TRGs provide a forum for discussing research ideas, operate a peer-support system for research bids, run multiple development activities (e.g. journal clubs and staff training sessions) and host external speakers. We provide all staff with a minimum annual personal development budget of £1,000 to support additional training and development needs not met through these processes, including travel and conference attendance, hosting collaborators, or specific technical training (e.g. cardiac imaging).

University-wide development programmes, relevant to the career stage, are also utilised within the School, including the Leader and Manger as Coach (2F: 3M), Navigator (1M), Springboard (3F) and Aurora (4F) leadership programmes, the latter to support growing our female research leadership capability. In addition, the Research and Innovation Staff Development Programme provides workshops on funding, publishing, data management, and media training to help staff disseminate their work and increase impact (REF5a, p.33); there were ~80 attendances at these workshops by SHES staff over the census period. We encourage staff to undertake other relevant university-level training to support an inclusive working environment; all staff within our Unit have completed training on 'Equality and Diversity', 'Unconscious Bias' and 'Bullying and Harassment'. A University 'Impact Accelerator Fund' (REF5a, p.12) is also available to support Impact, with £3,000 awarded to *Corbett* and *Tipton* to develop a school's water safety programme (*UoP24WATER*), as well as Erasmus+ funding, which has enabled *Dicks*, *Thelwell* and *Wagstaff* to undertake research collaborations with academic Institutions in France and Sweden. We also support external secondment where this contributes to staff development e.g. *Wagstaff* as EIS Head of Performance Psychology (6 months).

These processes are effective. Our staff feel that our Unit is meeting their development needs, with '*I am able to access staff development opportunities where needed*' among the three highest rated statements in the most recent staff survey. Our support, mentoring and development opportunities have grown the profile and reputation of our staff such that 100% (21 of 21) of our Unit now contribute to research income generation compared to 63% (5 of 8) in REF 2014. *Corbett*, *Lomax*, and *Dicks* have each secured their first medium-large grants (>£100k) as PIs, and our support helping *Eglin* to learn new methods was vital for securing substantial external funding (>£400k) to study cold injuries. In REF 2014, four of our submitted staff were responsible for the research underpinning our ICS (3F: 1M); this has grown to seven submitted staff in REF 2021 (4F: 3M). We have also promoted 62% of our Unit since REF 2014: eight to senior lecturer, *Burbage* to Grade 9, *Corbett* to Associate Head Research, *Wagstaff* to Reader, *Thelwell* and *Wakefield-Scurr* to Professor.

2.3 Training and supervision of PGRS

We have doubled our PGRS completions (10F: 6M [Table 2]) relative to REF 2014 and our PGRS community is complemented by other postgraduate research-based qualifications, such as PhD by publication (2M). Moreover, we have established the training and supervision

structures to grow this number significantly. Our 138% increase in PhD and Prof Doc registrations since REF 2014 shows that we are on-track to achieve this.

Table 2: Annual PGRS completions

Year	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Completions	1	3	3	2	0	3	4

In line with our inter-disciplinary approach and priority support for ECRs, we ensure our PGRS are supervised by a team containing a mixture of expertise and experience. We appoint additional external advisors where appropriate from academic, clinical, or sponsor organisations. Our student training occurs primarily in supervisory team meetings, which typically take place monthly with the primary supervisor, and quarterly for full-team meetings; the agenda, minutes and actions are recorded on an online platform (SkillsForge). All PGRS undertake an annual review to monitor progress and development and identify additional training needs. These processes enable our PGRS to enjoy exceptional supervision. In the 2019 Postgraduate Research Experience Survey (PRES), we achieved a 93% satisfaction score for 'supervision' and ranked in the top quartile of Sport and Exercise Science Departments for this measure.

Alongside the support and specific training provided by their supervisory teams, all PGRS attend at least ten days of researcher-development training each year. We provide a bespoke SHES training programme offering ~20 hours of discipline-specific training. Subjects include ethical considerations in sport science research, systematic review and meta-analyses in sport science, clinical trials and NHS ethics. Our programme is supplemented by the University-wide Graduate School Development Programme, which provides general research and transferable career-training skills as recommended by Vitae and RCUK (REF5a, p.38). Where appropriate, further training takes place with collaborators, such as Good Clinical Practice training through the PHUT, or biochemistry training with colleagues across the Faculty of Science and Health. All PGRS are members of a TRG and participate in its activities. This includes the 'Journal Club', where contemporary papers are reviewed, and the TRG seminar series, which includes PGRS presentations, a peer support system for developing research projects, and invited speakers. These activities develop critical thinking, provide networking opportunities, develop project design and grant writing skills, and serve as a stepping-stone to conference presentations. Our students also attend research seminars through the cross-school Institute of Biomedical and Biomolecular Sciences.

We support and encourage our PGRS to engage in a range of additional development activities to improve their employability, including placements, teaching activities and conferences. We offer conference bursaries to all PGRS to fund travel to at least one conference over the course of their studies. Our PGRS placement scheme has supported our students to spend time at academic and non-academic institutions in the UK e.g. Royal Hospital for Sick Children (Edinburgh), University Hospitals of Leicester NHS Trust, and Internationally e.g. Université de Toulon (France), where they learn techniques and methods to support their research and develop their networks. All students undertaking teaching activities are enrolled on the Graduate Student Professional Development (GPROF) programme, which is part of the University's APEX framework and enables them to work towards Associate Fellowship of the UK Higher Education Academy. We encourage our PGRS to participate in the School's Equality and Diversity

activities through involvement in groups such as 'Moving Womxn' and 'Diverse Action' (see Section 2.4). Our training and development portfolio is well-received by our PGRS, as demonstrated by a top quartile 'overall satisfaction' score (88%) in the 2019 PRES, and the quality of our PGRS is recognised externally, e.g. NATO Human Factors and Medicine Panel Excellence Award. Together, this prepares our PGRS for a range of successful careers, including research scientists, defence scientists, post-doctoral researchers, and academic and industry roles.

2.4 Equality and diversity

As well as adhering to the Race Equality Charter, the University is a Stonewall Diversity Champion, a member of Disability Confident, and holds an Institutional Athena Swan Bronze Award (REF5a, pp.43-45). At the School level, SHES has held an Athena Swan Bronze Award since 2015 and is working towards a Silver award in 2021. Our Athena Swan committee (7F: 2M) supports 'Moving Womxn', a student-led group from within SHES that aims to inspire and empower women to engage in physical activity and sport, and promote Sport and Exercise Science career paths. The group uses invited talks, podcasts, networking and social media engagement to reach their target audience, supported by SHES academic staff and PGRS as group members and content contributors. Our Unit supports flexible-working arrangements to accommodate staff caring responsibilities; this has been used by 19% of our Unit since 2014. We are also responsive to emerging equality and diversity issues. For example, during the Covid-19 pandemic, we ran a 'Conversation about Caregiving and Working during Covid-19', with Professor McMunn (UCL), to highlight gender inequality in domestic labour and raise awareness of the implications for SHES research during 'lockdown'.

Overall, 42% of SHES academic staff are female, which is in proportion with our submitted staff profile (43% headcount female) and above the discipline average of 37% (Advance HE, 2020). With a mean difference of only 4% (in favour of female staff) we have also achieved approximate gender-parity in pay. Of our submitted staff, 86% are less than 45 years of age. Although direct comparator data are not available, Advance HE data indicates that 82% of staff within the discipline were less than 50 years, suggesting that our Unit has a slightly younger than average staff profile. We selected our outputs according to the approved REF Code of Practice (REF5a, p.50). All staff involved in reviewing or selection undertook 'Unconscious Bias', 'Equality and Diversity', and 'Bullying and Harassment' training and our reviewing committee's gender-balance was consistent with our demographics (4F: 6M). We are confident that these processes enabled fair selection of outputs, irrespective of gender or status. Of our submitted outputs 43% are attributed to female staff, consistent with our Unit's gender balance. Similarly, ECRs are not under-represented (averaging 3.0 papers per ECR) and senior researchers are not over-represented (averaging 2.8 papers per Reader or Professor).

Five percent of our Unit have a self-reported disability, whilst none identify as 'BAME' (this terminology is used within current reporting systems). This profile is broadly consistent with discipline means (4.3% disabled, 3.7% 'BAME'; Advance HE, 2020). As part of our commitment to increase our 'BAME' engagement we have recently founded 'Diverse Action', a student-led group inspired by the Black Lives Matter movement that promotes equality for underrepresented groups within our subject, university, and beyond. We have a significant international presence within SHES, with academic staff from Ireland, Canada, Brazil, and Greece, and visiting

researchers from China, France, Brazil, Italy, Japan, Slovenia and Spain. Together, this reflects our inclusive, multi-cultural environment and prominent international reputation.

3 Income, infrastructure and facilities

3.1 Income

Our income strategy focuses on:

i) Sustaining our existing high-value funding relationships,

ii) Supporting and developing our researcher's expertise, profile and reputation to increase the number of staff generating income, and

iii) Progressively diversifying our funding portfolio to support our emergent research areas.

This strategy has enabled substantial growth in the volume and diversity of funding over this REF period. Our annual research income has increased by 71% compared to REF 2014 (from £201,717 to £345,154, see Table 3) and our annual knowledge exchange income has increased by 144%. We have increased the number of staff securing external funding as a PI by 350% and 100% of our Unit contributes to external income-generation. The number of staff securing grants over £100K has grown by 150%, and the number of individual funders of our research has increased by 83%. We continue to attract funding from a wide range of areas, including sports (e.g. England Athletics), defence (e.g. the Royal Air Force), industry (e.g. Speedo) and occupational groups (e.g. the Health and Safety Laboratory). The prestige of the groups funding our work (e.g. the Union of European Football Associations, the International Triathlon Union and the Fédération Internationale de Natation) demonstrates our international reputation in these areas. Our funding base has also expanded to include sports development groups (e.g. the 2nd Chance Group), local councils (e.g. Havant Borough Council), charities (e.g. the Brain and Behavior Research Foundation) and health groups (e.g. the NHS). Our funding growth and diversification reflects our enhanced capabilities and reputation, the relevance of our research to our funders, the efficacy of our funding strategy and support systems, and the vitality and sustainability of our Unit.

Table 3: Research income by year

Year	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Income	£251,805	£224,791	£173,545	£307,322	£438,184	£582,030	£438,402

In addition to the support and development mechanisms described in Section 2.2, our School provides ~£20k per annum to support staff with annual project costs (consumables, small equipment purchases etc). Where annual PDRs identify bid development as a strategic priority, staff are allocated 0.1 FTE within their workload plan. Within our TRGs, the mentoring from senior staff, sharing of established networks, and involvement of junior- and mid-career staff as Co-Investigators on research bids, was instrumental in supporting ECR *Stebbings* to obtain funding from the Active Communities Network as PI (£20k) and mid-career researchers *Lomax* (£122k), *Corbett* (£176k and £126k) and *Burbage* (£100k awarded 02.10.20) to obtain their first significant funding as PIs. The strategic growth of our health-related funding has been supported

by a Partnership Facilitator (a collaborative post between PHUT and the University of Portsmouth) and subsequently strengthened by a strategic partnership agreement between the two organisations (REF5a, p.16). Through new partnerships, we are now securing collaborative research grants that further expand our health-related research activity. Examples include *Saynor*'s (£94k) funding to undertake research with the Wessex Kidney Centre and *Perissiou*'s (£10k) ECR funding to work with the Victory Institute of Minimal Access Surgery. We are also enabling our staff to develop links with clinicians, physiotherapists, and clinical populations to sustain this positive funding trajectory.

3.2 Infrastructure

Our TRGs function as the organisational structure for coordinating research and impact activities, under the overall strategic guidance of the Associate Head Research. In addition to the leadership provided by the TRG leads, each TRG benefits from Professorial representation (*Tipton,* EE; *Wakefield-Scurr,* PAHR; *Thelwell,* IOOP), external national and international academic collaborators, and strategically-appointed visiting and honorary staff. We frequently host visiting researchers from other laboratories within the UK and internationally who are embedded within the relevant TRG. Research is supported by the School's technical team (2F: 5M), who maintain our unique facilities and equipment and have specialist expertise in programming, electronics, design and fabrication, enabling the manufacture of bespoke equipment to support our unique research (e.g. solar simulator). In line with our growth in attracting external competitive funding, a number of clinical studies also include research nurse support through their adoption onto the NIHR Clinical Research Network Portfolio.

The University follows the UK Research Integrity Office code of practice and adheres to the Universities UK Concordat to Support Research Integrity (REF5a, p.22). We support these at School level via a range of quality assurance processes that ensure sound research design, participant safety, adherence to ethical codes, openness and transparency. Our TRGs operate a peer-support system at the early stages of research design to ensure project rigour and quality and, where appropriate, bid-quality. Competitive external bid applications are reviewed through the University's 'Peer-review College' and, for projects involving clinical populations, our staff utilise the NIHR Research Design Service to develop their research protocols. Similarly, we utilise the relevant Ministry of Defence Scientific Advisory Committee for work with defence groups. Medical and safety aspects of our work with human volunteers are supported by our Independent Medical Officer, whilst our work with patients is also supported by our links with NHS clinicians. Our School research ethics lead provides guidance and support to our researchers, and our research with patients or military personnel is reviewed through the Health Research Authority Research Ethics Committee (REC) or MoDREC, respectively. For all other work we use the University's Faculty of Science and Health REC. We use the Portsmouth Research Portal to make our data publicly available and ensure our work is 'open access' (REF5a, p.24). Where appropriate, research is registered on clinical trial registers, which are updated on project completion.

3.3 Facilities

SHES is housed in the Spinnaker building, a purpose-built facility containing laboratories and seminar rooms, a computer suite, technical workshop and staff space. We have also established

a new, on-campus Strength and Conditioning facility, an off-site clinical exercise physiology laboratory and a field laboratory to support work with occupational and defence groups.

The Spinnaker building includes the Extreme Environments Laboratory, a specialist suite of three laboratories capable of controlling temperature (-20 to 50°C), humidity (10 to 90% RH), oxygen levels (up to 8,000m altitude equivalent), and simulating solar radiation and high wind speeds. These laboratories contain a swimming flume and immersion facility, with winch hoist and water temperature control. They are supported by a medical bay, rewarming area, drying room, preparation area and changing facilities. Since 2014, we have invested ~£1.1 million in infrastructure to optimise fine environmental control and maintain our world-leading capabilities (REF5a, p.64).

We also have an additional large, multi-purpose, research laboratory that can be configured in a variety of ways for bespoke research requirements, two further physiology laboratories, a smaller multi-purpose laboratory, a biomechanics and motor control laboratory, a psychology laboratory, and an interview and transcription room. The Spinnaker building connects to an adjacent sports hall and studio complex, equipped for research projects (e.g. *in situ* force plates), and our new Strength and Conditioning suite includes an Olympic lifting area and isokinetic dynamometer. Our £55 million sports centre (opening in 2021) will further enhance our *in situ* data collection capability. Off site, we have developed and equipped a research laboratory within the Wessex Kidney Centre (Queen Alexandra Hospital site). This enables exercise testing (functional testing to comprehensive cardiopulmonary exercise testing), analysis of biological samples and, in partnership with the cardiology department, echocardiography to assess cardiac structure and function. This resource has been critical to expanding our clinical research portfolio, while our field laboratory enables collection and processing of data from human volunteers in a controlled environment, and has underpinned our applied research with a range of occupational and defence groups, such as our cold injury research with military personnel.

Our laboratories are well-equipped with the array of methodologies, techniques and measurements typical within the cognate disciplines (psychology, physiology, and biomechanics), as well as specialist equipment aligned to the needs of each TRG. For instance, the Extreme Environments Laboratory includes infra-red thermography, skin blood flow measurement (laser Doppler), local sweat assessment (QSweat), local thermal stimulator and skin heating, a water proof metabolic cart and electromyography, an underwater cycle ergometer and a ladder-climbing ergometer. We have expanded our capabilities for health-related and occupational research through our investment in micro and macrovascular assessment, including transthoracic bioimpedance cardiography, iontophoresis, ischaemic reperfusion equipment, laser Doppler flowmetry and near infrared spectroscopy. To support our field data collection capability, we have also invested in portable data collection systems including GPS tracking and remote metabolic, cardiorespiratory, thermal, and biomechanical monitoring equipment (e.g. magnetic-inertial measurement units and accelerometers).

We finance our strategic investments in equipment through a combination of internal capital funding and external research funding. For example, quantitative sensory threshold testing equipment was purchased through defence research funding, whilst our clinical cardiorespiratory exercise testing capability was financed through funding from charities including ‘Cystic Fibrosis Kids’. In addition, our cross-school collaborations provide comprehensive biomarker

measurements (ELISA, HPLC, RT-qPCR, western blotting), gut microbiome assessment, endothelial cell cultures, ultrasound imaging and dual-energy x-ray absorptiometry.

Our unique facilities and infrastructure support a distinctive and impactful research profile. For example, our temperature-controlled flume and laboratory was used in research quantifying the thermal demands of swimming in different conditions. This research underpins water temperature limit rules used by the International Triathlon Union and the Fédération Internationale de Natation and is protecting athletes in over 200 countries (*UoP24ATHLETES*). These facilities, together with our solar-simulator, enabled research quantifying the thermal demands of swift-water rescue technicians, which has been incorporated into the UK (DEFRA) flood rescue policy (*UoP24WORKERS*). Our immersion facilities were used to assess the performance of emergency underwater breathing systems and provide the evidence for a new European aviation safety standard applying to offshore helicopter flights (*UoP24WORKERS*), as well as our research on water safety behaviours which underpins the RNLI's 'Respect the Water' campaign (*UoP24WATER*). Our environmental chambers, vascular assessment, and imaging capabilities supported research improving the diagnosis of cold injuries with UK defence groups (*UoP24WORKERS*), and the combined environmental stressor capability or our laboratories was used to undertake research that is enhancing the performance of Team GB Olympians (*UoP24ATHLETES*). Our field data collection capabilities have supported the development of fitness standards for a range of occupational groups, including the RAF Regiment (*UoP24WORKERS*).

Our facilities also support the public dissemination of our work and promotion of our discipline. They regularly feature in our media activities such as 'The Dr Who Gave up Medicine' (BBC One), 'Speed with Guy Martin' (Channel 4) and 'Respect the Water' campaign (RNLI), as well as in our applied work with Olympic athletes, charity fundraisers (see Section 4.2) and actors Jake Gyllenhaal and Josh Brolin in preparation for the filming of 'Everest'. They are utilised by other HEIs to train their post-graduate students (e.g. King's College MSc in Human and Applied Physiology), and underpin our Unit's industry partnerships in the areas of sports clothing, textiles design, and physiological monitoring and sensing.

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

4.1 Research collaborations, networks and partnerships

Our reputation for excellence in niche areas, combined with the staff support mechanisms described in Section 2 (e.g. travel, networking, conference attendance) has assisted our Unit to cultivate and sustain collaborations with HEIs spanning Europe, Asia, Australasia, North and South America, and Africa. These partnerships have generated 157 publications with UK academic collaborators and 154 publications with international academic collaborators since REF 2014. Unit members also hold visiting positions at academic institutions in the UK (e.g. Kings College London), Europe (e.g. the University of Ostrava) and Australasia (e.g. Queensland University of Technology) and have led on establishing international research networks. For example, *Tipton* is a founding member (in 2014) of the International Drowning Research Alliance, an international scientific network with 62 members from 15 countries undertaking drowning research and promoting water safety. Similarly, *Webb* (in 2016) founded the Referee and Match Official Research Network, bringing together researchers from six

countries with representatives from groups including the Union of European Football Associations, the Football Association, the French Football Federation, the Royal Dutch Football Association, and the England and Wales Cricket Board. Through these networks, we have highlighted the abuse of officials in sport across Europe, provided evidence supporting changes to international cricket rules, and developed a new framework for understanding drowning and guiding international drowning research.

Portsmouth's naval heritage underpins a number of established partnerships with key organisations who value our niche expertise in areas aligned to their requirements. This includes a 21-year working relationship between SHES and the RNLI, as well as a ~20-year relationship with the Ministry of Defence. During this REF period, we have collaborated on research with the Navy, Army and RAF on projects investigating women in ground close combat, cold injuries and heat illness, as well as with the Defence Science and Technology Laboratory on projects optimising soldier load-carriage, adaptation to heat, and the thermo-physiological burden of PPE. We also enjoy a 15-year collaborative relationship with the EIS (previously UK Sport), that has enhanced British athlete performance over four Olympic cycles and a relationship with British Triathlon spanning two Olympic cycles. Based upon our research, British Triathlon's heat preparation strategy won a 2020 UK Sport award for impact on high performance sport. More recently, we have strategically expanded our collaborative links with other non-academic research partners, such as the PHUT and University Hospital Southampton NHS Foundation Trust. Since 2014, we have developed research collaborations with the Wessex Kidney Centre, the Victory Institute of Minimal Access Surgery and the NIHR Wessex ARC.

Our network is further strengthened by the prestigious panel, group and committee positions held by members of our unit, which enable engagement with a diverse range of groups. Examples include the British Renal Society Rehabilitation Network, Energy Institute Health Technical Committee, EIS Technical Advisory Group, EIS Psychological Load Research Advisory Group, European Cystic Fibrosis Society Exercise Working Group, Cystic Fibrosis Trust Exercise Expert Group, Maritime and Coastguard Agency Lifejacket Expert Panel, Medical Committee for the Society for Anhidrotic Ectodermal Dysplasia, Ministry of Defence Non-Freezing Cold Injury Review Group (Chair), Ministry of Defence Surgeon General's Non-Freezing Cold Injury Research Steering Group (co-chair), Surf Lifesaving GB (trustee), Royal National Lifeboat Institution Medical & Survival Committee, and the UK Kidney Research Consortium Exercise and Lifestyle Clinical Studies Group. These established networks and relationships with a range of partners in areas aligned to our expertise are the foundation of our approach to developing societal benefits and impact. For example, our position within the Cystic Fibrosis Trust facilitated the incorporation of our clinical exercise testing research into the Standards of Care and Good Clinical Practice for the Physiotherapy Management of Cystic Fibrosis (2020). Similarly, our research on lifejacket use, undertaken through the Maritime and Coastguard Agency Lifejacket Expert Panel, informs Marine Guidance Note 588 (2018) and is preventing UK fisherman's deaths. The importance of these relationships in realising our research impact is further detailed in our ICS describing how our research benefits workers in arduous occupations (*UoP24WORKERS*), has improved water safety and reduced drowning deaths (*UoP24WATER*) and has protected and enhanced athlete performance in extreme environments (*UoP24ATHLETES)*.

4.2 Wider activities and contributions to the research base, economy and society

Our research outputs produced since 2014 have received ~3,900 citations across 97 countries, whilst our three ICS represent only a small fraction our work's positive societal impact. For example, our expertise has been used in medico-legal contexts to provide expert testimony in criminal trials and by the Global Strategic Council in their report on the effect of climate change on Cricket – a project using sport as a vehicle for raising awareness of the harmful effects of climate change. We were also the leading academic contributors to the Physiological Society and Guild HE's independent report to the UK Parliament detailing the benefits of Sports and Exercise Science in the UK; our research features as a 'Benefits to the public purse case study highlight'. Our Unit has supported a number of charitable groups and causes aligned with our research expertise, including Action for Oceans, CF warriors, the Ectodermal Dysplasia Society, and Diabetes UK. This has primarily been through supporting fundraisers undertaking physically demanding challenges, such as Josh Llewellyn-Jones, who has cystic fibrosis and completed a 21-mile swim, 200-mile cycle and 160-mile run over five days, and UN Patron of the Oceans, Lewis Pugh, who swam the length of the English Channel. The awareness raised by this 49-day swim contributed to the UK Government's commitment to advocating for protecting 30% of the world's oceans by 2030.

During the early stages of the Covid-19 pandemic, we worked with collaborators from the Jozef Stefan Institute (Slovenia) to develop personal protective equipment adapted from sports equipment and manufacture continuous positive airway pressure devices to support UK hospitals. Through our links with the Physiological Society and our network of internationally recognised academic collaborators and clinicians, we established, coordinated and contributed to 'Questions from the Front Line'. This online resource (https://www.physoc.org/covid19/questions/) allowed clinicians to ask questions and receive rapid input from over 30 of the world's leading physiologists, rapidly increasing understanding of Covid-19 pathophysiology. The site had ~5,000 views in three months and was awarded 'Best Member support during Covid-19' by the Association of Association Executives. In May 2020, we also ran an online conference providing guidance on 'returning to laboratory work', which was attended by ~650 delegates from 33 countries, with the resulting guidelines endorsed by the British Association of Sport and Exercise Sciences (BASES).

Our Unit has organised and hosted several prestigious International Conferences, including the 16th International Conference on Environmental Ergonomics (2015; 240 international delegates), the 3rd International Conference on Physical Employment Standards (2018; 140 international delegates), and the BASES Student Conference (2014). Through *Tipton*'s work with the Physiological Society, 2019 was designated 'The Year of Extreme Physiology', and our Unit hosted the 'Extreme Physiology: Life at the Limits' Conference (2019; 220 international delegates). Our staff hold esteemed positions with numerous academic journals, including: Editor in Chief: *Experimental Physiology*; Editor: *Sport and Exercise Psychology Review*; Editorial Board: *European Journal of Sports Sciences*; *Experimental Physiology*; *Journal of Sports Biomechanics*; *Case Studies in Sport and Exercise Psychology*; *Soccer & Society*; *International Review of Sport and Exercise Psychology*, *International Journal of Sport Psychology*; and Associate Editor: *Journal of Sports Sciences*; *Journal of Applied Sport Psychology*, *International Journal of Sport and Exercise Psychology*, *Journal of Sport Psychology*; *Case Studies in Sport and Exercise Psychology*. Our Unit has also provided expert

review for funding bodies e.g. Biotechnology and Biological Sciences Research Council; National Institute for Health Research; Multiple Sclerosis Society; National Research Foundation South Africa; Academy of Medical Sciences. We have delivered more than 400 invited presentations over the census period, and our expertise positioned us to lead three BASES expert statements and contribute to an International Olympic Committee consensus statement. Our staff's contributions have been recognised though prestigious awards, such as an MBE, Ireland Medal and the Physiological Society's GL Brown prize (*Tipton*), the Dorothy Harris Memorial Award (*Wagstaff*), and the Emerald Literati Award (*Gorczynski*).

We have strong links with our local community through our strategic-partnership with Portsmouth Football Club (REF5a, p.16) and engagement with a diverse range of local groups, including the Portsmouth Pensioners Association, Civil Service Pensioners Alliance, University of the Third Age, Science Discovery Group, Women's Institute, and DESMOND (type 2 diabetes). Our research involves a range of community groups, including school-children, clinical cohorts, athletes, and offenders, and at different stages of the research cycle, including design (through Patient and Public Involvement), participation, public engagement and dissemination, and impact. We have inspired the next generation of Sport and Exercise Scientists through the 'Speakers 4 Schools' programme, 'Inspiring Girls' online platform, and our schools' masterclass workshops and annual Christmas lecture. Our staff have also widely disseminated their work through the 'Pint of Science' lecture series and online platforms, such as Reddit's 'Ask Me Anything'. We have been prominent in publicising our work, and the Sport and Exercise Science discipline more generally, through various media, including web, print and television. This is exemplified by the media engagement evidenced in our ICS (*UoP24WATER*), whereby *Tipton* served as the scientific advisor and spokesperson, featured in filming undertaken in our laboratories, and provided multiple interviews for an international, multi-media, water safety campaign ('Respect the Water', RNLI). This media reached 46,000,000 people in 2018, and has increased water safety awareness, changed behaviour and saved lives.