

Institution: University of Leeds (UoL)
Unit of Assessment: UOA24 Sport and Exercise Sciences, Leisure and Tourism
<p>1. Unit context and structure, research and impact strategy</p> <p>1.1 Context and structure</p> <p>Our UOA24 submission includes 25.3 full time equivalent staff. Academics are mainly in the School of Biomedical Sciences, Faculty of Biological Sciences (FBS) but come together with the School of Medicine, Faculty of Medicine and Health (FMH) to address key health-related issues in the science of exercise, movement and physical activity. The close association between basic and clinical sciences is key to the vitality and sustainability of the Sport and Exercise Sciences (SES) UOA, evidenced by cross faculty publications, collaborative grants and common strategic goals. The interdisciplinary nature of our work ensures extensive collaboration with academics returned in other UOAs and university wide centres (Figure 1) and regional NHS Trusts (including Leeds clinical research facilities) to produce research excellence of broad relevance to human health and well-being, across the spectrum of exercise intolerance to enhanced performance. Building on the REF2014 strategy to provide sustainable delivery of high-quality translational research outcomes on a foundation of basic science, our strategy is to understand the relationships among physical activity, functional optimisation, health and predisposition to chronic non-communicable conditions such as obesity, diabetes and cardiovascular disease.</p> <p>Our current research strategy has reinforced our position amongst the leading SES research groups and educational organisations, increased research income and maintained buoyant recruitment of leading research-active staff through 3 research groups (Figure 1): Cardiovascular and Exercise Physiology (CEP), 13.5 FTE; Biomechanics and Tissue Engineering (BTE), 5.8 FTE; Motor Control and Exercise Psychology (MCEP), 6.0 FTE. Of note, since 2014 the formation of BTE has increased the success of interdisciplinary research activities that link this UOA with other UOAs and multidisciplinary clinical and technology focussed centres that provide platforms for impact (Figure 1).</p> <p>MCRC - Multidisciplinary Cardiovascular Research Centre LIDA - Leeds Institute for Data Analytics LBRC - NIHR funded Leeds Biomedical Research Centre iMBE - Institute of Medical and Biological Engineering MTIKC - Medical Technologies Innovation and Knowledge Centre NeuR@L - Neuroscience at Leeds</p>
Figure 1 Research groups with subgroupings, associations with other UOAs and Multidisciplinary Centres, supported by significant investment by UoL.

The highly collaborative, interdisciplinary nature of our research, and focus on global health challenges, underlies the sustainability of SES. Much of our research has translational relevance which extends, e.g. from drug or nutrition-based interventions, to the role of exercise and lifestyle changes in the maintenance of health, well-being and the treatment of disease. National and international collaborations contribute to high numbers of outputs, impact activities and grants. During the REF period, academics in UOA24 were awarded £9.7M in grants (as PIs or CoIs) and authored >300 research articles with over 35% in the top 10% journal percentile. Four new staff members secured external fellowships from UKRI, Royal Society and Marie Curie. We continue to invest in our research environment through improvements in infrastructure (£32.3M) to enhance collaborative research space and new facilities (£17.0M).

1.2 Research and impact development strategy

Our research reaches across the lifespan to examine the dynamic relationship between activity patterns, physical and mental health, predisposition to and recovery from chronic conditions and limitations to mobility. This requires a broad molecular-to-cell-to-systems research portfolio, supporting diagnostic and stratification approaches, with impacts ranging from physical capability (e.g. neuromuscular control) and optimal physical performance (e.g. movement efficiency) to improved health and well-being.

Our aim is to enhance our world-class research activity, **through strategic appointments (11), interdisciplinary research, national (Figure 2) and international (Figure 3) links and use of new technologies**, such as neuromodulation and high resolution motion capture (**section 3**). We boost reach and impact through exploitation of our translational focus and interdisciplinary research programme. Impact is achieved via development of innovative solutions to major societal challenges.

Our strategy for the future 5 years is to extend the practical application of interdisciplinary basic science, harnessing knowledge of physiological/psychological mechanisms to drive translational benefit and informing rehabilitation outcomes. Thus, the main non-academic beneficiaries are patient groups, healthy ageing populations, industrial partners, practitioners, professional services, UK and overseas governments and policy makers (**section 4**).

Aligning SES research with national and international priorities

Our responsive research groupings ensure continual alignment with global (e.g. UN sustainable development goal on good health and well-being) and national strategic priorities. These include MRC focus on resilience, repair and replacement, EPSRC aim to accelerate translation to healthcare applications, BHF strategy to support cardiovascular health and the BBSRC focus on healthy ageing. Indeed, we have demonstrated success in MRC funding of exercise interventions (e.g. £700K) and cardiac dysfunction in ageing and heart failure (£1.1M). Research also aligns with the WHO Global Action Plan on physical activity 2018-2030, which states the importance of regular physical activity to reduce prevalence of non-communicable diseases such as heart failure, stroke, diabetes and cancer.

Our agile approach to the changing research environment is exemplified by the Culture, Health and Well-being Alliance recognition as best practice of the adaptation of the Dance On Partnership Project (Astill) for online delivery during the Covid-19 pandemic. This has recently led to further funding from Sport England.

Enhancing interdisciplinary research

Our staff engage extensively and successfully across the University, the UK and the World to boost outputs, enhance translational aspects of the research, and develop new technologies. For example, a high percentage of submitted outputs are with other Leeds UOAs (39%), other UK institutions (47%) or involve international co-authors (59%) and we have collaborative grants with other UOAs (49%). Our research involves collaborators from 24 UK institutions and 30 countries (Figures 2,3). Working within multidisciplinary research centres (Figure 1), we draw together expertise in science, engineering, innovation and medicine to ensure translation of scientific

discovery into treatment. To enhance our international profile and reputation, a new Pro-Dean International position (initiated in 2018) engages with international partners and stakeholders.

Investing in people

Eleven new staff were recruited to UOA24 during the REF period, across all 3 research groups, enhancing research vitality and bringing new collaborative opportunities (section 2). These are supported by active mentoring, information exchange sessions, pump priming research funds (up to £100K/person) and the provision of a university funded postgraduate student. Combined with an initially low teaching load, this approach underpinned 20 new grants awarded to new appointees as PI (£3.5M). Staff are supported to succeed in their research strategy by the Director of Research and Innovation (DoRI) and research group leaders, who provide mentoring and coordinate their research environment, encouraging strategic alignment with targeted funding avenues. Support for impact is provided, with appropriate workload allowance and recognition of impact in the promotion criteria.

Encouraging an open research environment

Data from research are shared openly and extensively. Beyond open access (see REF5a), resources such as source code (which underlies the models, algorithms and/or analysis in publications), supplementary datasets or software developed for use by the academic community are made freely available online, hosted through appropriate repositories (e.g.github) and linked from websites. Raw data and representative images are freely available in the Research Data Leeds Repository, providing a unique DOI for public access included in publications or on laboratory webpages. Transcriptomic and proteomic data from tissue collected from patients and animal models of heart failure are available on ArrayExpress/EMBL-EBI database. UoL is committed to responsible practices in research evaluation by signing the San Francisco Declaration of Research Assessment (DORA).

Embedding Impact

Translational impact is supported through a Research and Innovation Development Manager (RIDM, 1.0FTE), Research Impact Officer (0.5FTE) and secretarial support (0.2FTE). Together with an Impact Champion embedded within UOA24, they enhance grant proposals and impact documents, deliver impact from fundamental research discoveries, and help develop Proof of Market and Proof of Concept proposals. For authors of ICSs, there is protected work time and funding to enable stakeholder meetings, data gathering etc. At Faculty level there is an impact support fund (£465k in this REF period) which includes the BBSRC Excellence with Impact runner-up award. MRC Confidence in Concept and Proximity to Discovery grants, administered in the university, have supported the creation of translational impact and academic-industry collaborations. The strategy has increased the translational impact of research in UOA24 and resulted in case studies that reach beyond health and welfare, by impacting directly on practitioners, policies and the public. Examples of these impacts are detailed in **section 4** and our impact case studies (ICS) simply showcase examples across this discipline. Development of new interactions with companies to increase impact is supported at the University level by a Commercialisation team, the MTIKC and the newly completed Nexus Centre, enabling businesses from all sectors to connect with academics at Leeds to maximise innovation and commercial returns. These are already proving fruitful, with meetings between academics and SMEs leading to recent grant awards and applications (**Astill, Birch, Deuchars, Tierney**).

Ensuring strong ethical governance

UoL policy requires approval of all research with an ethical dimension by a University research ethics committee or the NHS Integrated Research Application System. This ensures compliance with the University's values of academic excellence, community, integrity, inclusiveness and professionalism (REF5a). Local Research Ethics Committees operate under delegated authority to consider the likely benefits of research involving human participants or their data in relation to the potential risks. Research involving animals follows Home Office requirements and guidance and is reviewed separately by the University's Animal Welfare and Ethical Review Body that includes active research staff and lay members.

1.3 Research and Impact Delivered During the REF Period.

We have 3 research groups with extensive interaction between groups to ensure high impact.

Group 1. Cardiovascular and Exercise Physiology (CEP), 13.5FTE (new appointees in *italics*): Leader: Egginton (0.8FTE), Members: Benson, Birch, *Bowen*, Calaghan (0.8FTE), *Colman*, Colyer, Deuchars, Ferguson, Lancaster, Rossiter (0.2FTE), *Smith*, Steele, White (0.7FTE), Witte.

Academics use an integrative bench-to-bedside approach to define the normal scope for cardiorespiratory and muscular function that limits exercise capacity, and understand mechanisms underlying disease progression and rehabilitation strategies. This involves a range of approaches from cellular, molecular and biochemical studies to experiments in animal models or human participants, underpinned by *in silico* models of disease. Close associations with research centres (MCRC) and cross faculty groups such as NeuR@L and LeedsOmics, all of which include clinicians, enable translational impact to be realised.

Studies into the mechanisms of blood vessel growth use interdisciplinary approaches to ameliorate tissue ischaemia and reduce muscle frailty in cardiovascular diseases. Utilising cellular and molecular responses, new therapeutic avenues are defined, e.g. small molecule therapies, alongside exercise interventions in ageing and sarcopenia (**Bowen**), or mechanisms limiting skeletal muscle oxygen uptake and causing fatigue (**Benson, Egginton, Rossiter**). The interplay between vascular function, exercise, ageing and cardiovascular disease spans cellular, medical, and community-based activity. Exploring the potential of stem cell mobilisation and recruitment in promoting vascular and cardiac health (**Birch, Smith**), complements identified clinical imperatives to stratify treatment among chronic heart failure patients with co-morbidities such as diabetes (**Witte, Bowen**). The challenge of evidence-based advances in understanding aetiology and treatment of cardiopulmonary diseases has benefitted from coordinated small-scale experiments and large-scale clinical trials (**Rossiter**). An integrative approach addressing skeletal muscle and autonomic dysfunction in animal models and patients provides insight into effective interventions to ameliorate exercise intolerance and improve quality of life. Innovative techniques of non-invasive neuromodulation (**Deuchars**) and bespoke exercise modalities (**Ferguson**) have direct translational benefit in developing more effective patient rehabilitation strategies.

A major strategic aim is to address the prevention and treatment of cardiac disease by focusing on arrhythmia mechanisms (**Lancaster, Steele, White**), right heart failure (**White**), the role of the beta-adrenergic signalling pathway (**Steele**) and the use of exercise as a rehabilitation strategy for skeletal muscle dysfunction developed as a comorbidity in heart failure or ageing (**Calaghan**). In parallel studies, magnetic resonance imaging in animal models of disease (**Benson**) and novel multi-scale computational models of cardiac electrophysiology (**Colman**) inform a more granular physiological understanding of cardiac and skeletal muscle, and cardiopulmonary regulation and dysfunction. Pathological mechanisms are identified using predominantly molecular and biochemical techniques, e.g. post-translational modification of key proteins and site-specific modifications in pathology, or use of super resolution imaging to explore intracellular signalling nanodomains (**White, Colyer**). These synergise with studies addressing changes in membrane structure and intracellular Ca^{2+} handling in skeletal and cardiac muscle (**Calaghan, Steele**).

Our future strategy will exploit fully the interface between established cardiovascular and exercise research activities and new areas of expertise, to identify novel opportunities for therapeutic intervention. Formation of specialised subgroups serve as a launch pad for the development of ambitious programmes of work, targeting longer, larger and multicentre research funding.

Research and impact highlights:

1. Improving lives of patients with chronic cardiovascular or pulmonary diseases by contributing to position statements and treatment guidelines (**Section 4**).
2. Developing novel insights into origins and therapies for pulmonary hypertension as an important complication of heart failure (**UOA24-224,UOA24-225,UOA24-226,UOA24-227**).

3. First evidence that the Golgi apparatus operates as a functionally distinct Ca^{2+} signalling organelle in adult cardiac myocytes (**UOA24-505**).
4. Establishing the role of statins in skeletal muscle myopathy and possible interactions with exercise (**UOA24-474**).
5. Evidence that high dose vitamin D3 supplementation is associated with a significant improvement in cardiac function in patients with chronic heart failure (**UOA24-2176**).
6. A spinout company (Badrilla), producing antibodies and specialist research reagents (**Colyer**).

Group 2. Biomechanics and Tissue Engineering (BTE), 5.8FTE: Leader, Askew. Members: *Berry (0.8FTE), Edwards, Fermor, Tierney, Walker*.

This group has research interests ranging from fundamental science to translational medicine and emerging technology.

We use integrative and comparative approaches to understand how muscles optimally deliver both powerful and controlled locomotion, and to identify the trade-offs underlying performance (**Askew, Walker**). Detailed computational biomechanical models allow the replacement, refinement and reduction of animal experiments, while facilitating targeted exercise interventions. State-of-the-art measurement and analytical techniques exploring one of nature's most intractable biomechanical systems, the insect flight motor, will inspire development of bio-inspired micro-robotics and air vehicles, and aid design and control of micromechanical systems. Synchrotron and high-speed visual imaging, image analysis and mathematical modelling approaches are essential for such realistic modelling (**Walker**). Understanding the anatomical, physiological and biomechanical adaptations and constraints underpinning healthy locomotion is central to developing an understanding of dysfunctions occurring with age or disease. This knowledge has translational benefit demonstrated by understanding the impact of prosthetic limb design on locomotor performance. Our translational expertise in biomechanics is supported by the latest appointment (**Tierney**), who applies multibody modelling and wearable technologies to mitigate the impact of head trauma in contact sports.

Academics are actively involved in iMBE - a leading global centre of excellence in biomedical engineering with over £30 million research funding and LBRC - an international centre of excellence in musculoskeletal disease research. Recent research focusses on the development of early intervention therapies, such as injectable peptide hydrogels and implantable acellularized scaffolds for musculoskeletal damage (**Fermor, Edwards**). Recruiting expertise in tissue replacement and regeneration led to elucidating the mechanisms of immunomodulation and tissue regeneration in acellular scaffolds for cardiovascular repair and replacement (**Berry**).

Our future strategy is to integrate further our extensive expertise of biological function from cells to human, with our evolving technological capabilities and biomedical engineering, to develop solutions to hitherto intractable problems that limit healthy activity.

Research and impact highlights:

1. Successful commercialisation of a de-cellularisation process for porcine heart valves and pericardium, leading to clinical success [**UOA24-2**].
2. Novel mechanisms of mosquito flight, described in *Nature* paper, revealed a unique pattern that may aid development of flying microrobots (**UOA24-3747**) with the impact of insect biomechanics research at Leeds highlighted by the BBSRC (**Walker, Askew**).
3. The development of novel early-intervention regenerative therapies for cartilage repair to prevent or delay the onset of osteoarthritis (**Fermor**).
4. The application of wearable technology and computational biomechanics led to new law trials and policy change for head and neck injury prevention with World Rugby and the Rugby Football League (**Tierney**).

Group 3. Motor Control and Exercise Psychology (MCEP), 6.0 FTE: Leader, Ichiyama. Members: Astill, Burke, *Delis*, *Divine*, *Nykjaer*.

This group focusses on maintaining healthy lifestyles, regaining exercise capacity and improving physical activity in clinical populations of all ages, including children, pregnant women and the elderly. The ultimate goal is to improve rehabilitation outcomes, maximise functional recovery, and increase the understanding needed to optimise employment of exercise for rehabilitation. MCEP uses diverse approaches to understand and develop new treatment strategies for motor dysfunction in spinal cord injuries, palliative care in cancer and sensory-motor function in healthy and clinical populations. It also explores physical activity behaviours and lifestyle during pregnancy and maternal health (**Nykjaer**). MCEP fosters extensive collaboration with the healthcare sector. Psychological and behavioural approaches are embedded in MCEP research, exploring the benefits of exercise and engagement in physical activity in a range of populations including cancer patients and survivors (**Burke**) and interaction of cognitive function with movement control in patients with dementia (**Divine**). Approaches span cellular physiology and morphology, whole organism behaviours, and ethnographical research. Facilities enable study of three-dimensional control of movement, using surface and indwelling electromyography. Central nervous system physiology, morphology, computational modelling and pharmacology (**Astill**, **Ichiyama**, **Delis**) are assessed in humans and animals with a range of neurological disorders.

Our future strategy is to advance new treatment approaches for motor dysfunction in spinal cord injuries, palliative care in cancer and sensory-motor function in healthy and clinical populations. MCEP is expanding interdisciplinary research, while pursuing approaches that employ cellular physiology and morphology, whole organism behaviours, and ethnographical research. We make strides in patient centred research through work with the health care community, professionals and patients, garnering translational impact (**Section 4**).

Research and impact highlights:

1. Demonstrating the effects of specific rehabilitation parameters and neuromodulation in combination with plasticity enhancing interventions in locomotion and micturition following spinal cord injuries. [**UOA24-1**].
2. Establishing guidelines for exercise in palliative care implemented across Sue Ryder care homes [**UOA24-3**].

Developing a unifying model of modularity in muscle activity, which yields a compact representation of neuromotor signals and a reliable prediction of the task at hand (**UOA24-3833**).

2. People

2.1 Recruitment Strategy and Staff Development

Our well-defined organisational structures and investment in people resulted in buoyant recruitment of leading research academics (Table 1). Our recruitment strategy ensured that research interests of appointed staff aligned within established research groups. A key aspect of our strategy is to exploit the interface between our established research activities and new areas of expertise provided by the appointees, all of whom have been recruited at the level of Early Career Researchers (ECRs)

In CEP, we recruited staff with research expertise in the use of animal models of heart failure and skeletal muscle dysfunction (**Bowen**), stem cells and their role in maintenance of cardiovascular function (**Smith**) and advanced computational modelling capable of integrating data from subcellular compartments to the level of the intact organ and pulmonary hypertension research (**Colman**). In BTE, strategic recruitment of high quality researchers enhanced critical mass in biomechanics and tissue engineering, to form a new multidisciplinary research group. Targeted recruitment in MCEP of 3 academics added to one of few centres in the UK housing a critical mass of staff with interdisciplinary expertise in the psychology and neuroscience of motor control.

Table 1 UOA24 recruitment over REF period (all ECRs)

	CEP	BTE	MCEP
Lecturer/Assistant Professor (grade 8)	Bowen, Smith	Fermor (F), Tierney	Delis, Divine (F), Nykjaer (F)
UAF	Colman	Berry (F), Edwards (F), Walker	

In 2014, the University invested £100M into the Great Minds University Academic Fellowship (UAF) scheme, to recruit internationally competitive future academic leaders. UAF appointments received a five-year tenure track contract and development scheme leading to permanent Associate Professorship appointment. UOA24 successfully recruited 5 UAFs, who obtained substantial funding since their arrival. One was recently recruited as a senior associate consultant at the highly regarded Mayo Clinic, USA. Their new awards averaged £630K/FTE. Crucially, these appointments, both lecturer and UAF level, have focussed on interdisciplinary research: **Edwards** was appointed jointly by Engineering and FBS, as part of iMBE; **Berry** maintains links with industry; **Colman** enhances capacity in established computational modelling and imaging research; **Bowen** has clinical links for research into exercise regimes as treatment in cardiorespiratory conditions. Two UAFs were externally funded research fellows who we mentored through the application processes and placed with senior mentors in appropriate thematic areas: **Walker** (Royal Society), **Colman** (MRC).

In total, 27 staff (25.3 FTE) are returned, of whom 6 are Professors, 8 Readers/Associate Professors, 9 Assistant Professors and 4 UAFs. We return 39% of staff aged <40y, 32% aged 40-49y, 23% aged 50-59y and 6% >60y, reflecting future vitality of the UOA. Of these, 41% are female and 59% are male, higher than 2014 when 36% of staff were female. All aspects of EDI were evaluated via a Faculty and University process to ensure no one was disadvantaged with respect to inclusion in REF and choice of outputs. The needs of staff with respect to flexible and/or reduced working are constantly considered and reflected in the return of 5 staff on less than 1FTE.

All recruited staff receive start-up funds (up to £100K) to pump prime research, provide support for travel and enable access to facilities. UAFs are provided with a PhD studentship, and other recruits were similarly supported by mechanisms, such as PhD demonstratorships (see below). Moreover, new lecturers and UAFs receive significant workload remission for 3 years e.g. in year one, teaching and administration load is ~33% of non-ECR academics. Throughout probation, they receive active mentorship from a senior academic staff member (separate from the probation advisor) and 6-monthly formal meetings with their mentor, Head of School (HoS), DoRI and Director of Student Education (DSE).

To promote inclusivity during recruitment, we embed actions such as debiasing recruitment adverts, diversifying locations of advertising, optimizing use of professional networks and LinkedIn and producing short films on life as an employee at UoL. To ensure sustainability of staff and infrastructure, each Faculty has an academic and financial 5 year plan agreed annually with a top level University team. To cement our interdisciplinary approach, we recruit to enhance collaboration across traditional disciplinary boundaries e.g. between biology and mathematics, medicine, engineering or environment. The formation of the BTE group is an example of our success in promoting interdisciplinary research.

2.2 Support and Development of Staff

We develop and promote our staff, helping them achieve goals that are in line with our research ambitions. Post-probation, all academic staff are mentored and development facilitated in annual academic review meetings between individuals, HoS, DoRI and DSE. Workloads are assessed and redistributed as needed, allowing staff to tackle strategic or time sensitive objectives (e.g. in response to COVID-19). This helps staff achieve their potential by providing the opportunity for 2-way review of work progress, identifying key objectives, providing constructive feedback, recognising success, supporting improvement, identifying and planning appropriate development, and discussing career aspirations. The value of mentoring is reviewed each year and new mentors

developed, both within and outside UOA24. To facilitate staff development, a wide range of opportunities are available centrally, through Operational Development and Professional Learning (OD&PL, REF5a), who run research culture cafes to promote a positive and inclusive research culture.

Our success in staff development, reward of research accomplishment and external recognition is indicated by promotions in the REF period (1 Professorship, 3 Associate Professorships, 1 Research Fellow to UAF). We also recognise success (not just research-related) with a financial incentive through the reward and recognition scheme, which is open to all stages of career and celebrate success in the Dean's communication and UoL success pages.

We are committed to the Concordat to Support the Career Development of Researchers and adhere to the established University Policy on the Employment of Researchers to implement this approach. Our support of postdoctoral researchers (PDRAs) is enhanced by an academic postdoctoral champion, who also contributed to the institutional level HR Excellence award in 2019, and a committee of PDRAs to ensure that the needs of these valued members of our community are fully considered. All PDRAs undertake at least 10 training days per year and opportunities for developing teaching supported, which has enabled interested PDRAs to obtain HEA Associate Fellowship. Local mentoring circles for PDRAs, aligned with 2 academic mentors from different backgrounds provide informal support for career development and any other advice. The PDRA community organises a "Coffee and Careers" series, with outside speakers talking about their postdoctoral careers outside academia. To foster research independence, the Dean's Vacation Research Scholarships enable PDRAs to gain experience in leadership skills including applying for funding, advertising for and interviewing students, supervising them for 8 weeks and writing a final report. The UoL is also a signatory to The Technician Commitment and we have realigned technical structures to promote clear, transparent career pathways.

2.3 Equality and Inclusion – Good Working Practice

We are committed to delivering a supportive and professional working environment for all staff, through embedded practices supporting equality, diversity, protected characteristics, disabilities and flexible working. To set local policy and ensure implementation of local and University policy, each faculty has its own Equality and Inclusion Committee, chaired by the Dean and attended by Pro-Deans and HoS.

In 2017, an Equality and Inclusion coordinator was appointed, leading developments of:

- Establishment of a FBS Well-being room
- Introduction of training sessions on Unconscious Bias and Equality for academics, PDRAs and PGRs
- Trans awareness training
- Campaign to represent the diversity of staff and students under the slogan FACES OF FBS
- LGBT Science, Technology, Engineering, and Mathematical (STEM) events
- Faculty Diversity Awards, funding attendance at BAME-ECR conferences for young BAME scientists
- Establishment of Wellbeing Works, a peer support initiative run for, and by, PhD students.

We strongly support the development of women's careers in STEM disciplines, recognised by Athena SWAN Bronze award in 2014, and elevation in 2020 to Silver award. Athena SWAN led the introduction of funding of PDRAs to support academics on prolonged leave (e.g. maternity leave), which enabled better maintenance of research output and productivity. New initiatives to support grant writing led to an increase in female staff contribution to successful applications (from 16% in 2016/17 to 46% in 2018/19). Funding for leadership training for women (e.g. Aurora, Springboard) contributed to an increase in the % of leadership roles held by females (55% of posts in 2018/19 compared to 26% in 2016/17). Indeed the Executive Dean for FBS, and DoRI are female academics returned in UOA24.

We will continue to review current practices annually through 'Culture Surveys' and focus groups on flexible working, mentoring, career progression and returning to work. These highlight good practice and provide an action plan to continue progression in equality and inclusion. We actively participate in workshops on flexible working to improve understanding for staff and managers. Speakers include academics from UOA24, who bring their experience of flexible working and offer mentoring to those considering part-time work. Staff with disabilities are provided with specific support or adaptations to enable full inclusion and monitored by Faculty Health and Safety and Occupational Health. An autism awareness workshop also runs regularly. **Deuchars** is an Equality and Diversity Champion and as part of this, introduced the first event for LGBTQ+ inclusivity in The Physiological Society. We have open Athena SWAN coffee meetings to encourage lively discussion of gender equality issues such as barriers to career development, 'everyday sexism' and core hours. We now run an everyday sexism campaign in response to this discussion.

2.4 Research Students

We have a vibrant and active group of postgraduate researchers with 129 PGRs either completing or undergoing PhDs during the reporting period. The average number graduating per year is 86% higher than the last REF period. Furthermore, increasing numbers reflect recruitment of new staff into the supervisory pool and demonstrate upward trajectory, with 70 PGRs currently enrolled on postgraduate research degrees. We have more overseas (16%) and female (50%) PGRs than last REF period and of those graduating, 3 completed on a part-time basis. These PGRs contributed to over 43% of the overall eligible outputs, higher than last REF period (around 20%) and 56% of these had PGRs as first or last authors. PGRs have a primary supervisor responsible for direction of the research project and at least one co-supervisor.

Each PGR is registered within either School of Biomedical Sciences or School of Medicine, with co-supervision integrated across other Faculties e.g. Engineering, Physical Sciences and institutes outside of Leeds. Co-supervision is further enhanced through multidisciplinary research centres, such as iMBE and MCRC – the interdisciplinary nature of the supervisory team is especially highlighted by Table 2 since 48 of the 59 people graduating had co-supervisors outside UOA24. In this challenging area for external studentship funding, academics benefit from 2 internally-funded PhD demonstrator positions per year. These PGRs experience teaching and assessment as well as research training, enhancing their academic career prospects. We also participate in cross-faculty PhD initiatives such as MRC DiMeN Doctoral Training Partnership (DTP) with Sheffield, Newcastle and Liverpool (3 students at present), BBSRC DTP (5 students) or the EPSRC Centre for Doctoral Training in Tissue Engineering and Regenerative Medicine (15 students), which enables development of interdisciplinary research. These include co-supervision with Food Science (2 academics), Engineering (2 academics), FMH (7 academics). We also recruit PGRs funded on iCase studentships (**Deuchars, Colyer**) while a unique collaboration with Medtronic (**Witte**), the world's largest manufacturer of pacemakers, supported four PGRs, two of whom are allied health professionals, delivering the foundation for 3 subsequent NIHR fellowships.

FBS established the first Graduate School on campus and initiated regulatory procedures that are now followed across the University. We utilise a University Code of Practice on PGR supervision. The Graduate School coordinates and administers all postgraduate training and supervision, through training plans and the GRAD system. The supervisory team includes two assessors from within the university who have relevant experience, meeting formally with the PGR to review progress at defined time points. These include: evaluation of a grant proposal or literature review (year 1); a transfer viva, examined by written report and *viva voce* (end of year 1); a draft manuscript (year 2); a thesis plan at the end of the penultimate year.

Our successful PGR supervision is reflected in an overall pass rate on first submission of >98% (average 2017-2020). Overall submissions within four years is >78% (average 2017-20), and 8% of PGRs submitted after an approved hiatus for health or personal reasons. These PGRs are returned as having submitted within 4 years and the resulting calculation shows >82% of our PGRs submitted within 4 years. Our PhD graduate first destinations are principally science related, with >80% undertaking postdoctoral research, employed in relevant industries and the NHS or in science-related roles such as science admin, policy, publishing or consultancy.

Doctoral degrees awarded	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	Total
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Professional research doctorates						1 (0.35)		1 (0.35)
Other doctoral degrees.	2 (1.5)	4 (2.9)	8 (5.09)	10 (6.75)	7 (4.9)	12 (7.7)	15 (7.0)	58 (35.84)
Total	2 (1.5)	4 (2.9)	8 (5.09)	10 (6.75)	7 (4.9)	13 (8.05)	15 (7.0)	59 (36.19)

Table 2. Number of students awarded PhD or professional doctorates per year.

Total number of people awarded degrees is given (values in brackets reflect co-supervision from other UOAs).

PGRs receive at least 10 days per year of professional development training. OD&PL provide soft-skills training, including a broad range of workshops and events that support PGRs as they embark on research, and develop key skills for future careers within or outside academia. Examples include: project management; thesis writing; working with your supervisor; viva preparation; creative thinking and problem solving; effective networking. More bespoke training is also available, such as Leeds Omics workshops, Good Laboratory Practice. OD&PL together with the University Mental Health and Wellbeing service provide training sessions around resilience and well-being. Academics also provide training on reviewing manuscripts for both their PGRs and PDRAs.

Our professional development programme is under constant review to reflect perspectives of, and relevance to, Research Councils and employers, resulting most recently in additional workshops on enterprise, public engagement with science, pathways to impact and working with industry. The paper and grant peer review process extends to PGRs to improve publication and external funding application rates. PGRs attend regular seminars across the university, with the breadth of seminars reflecting the interdisciplinary nature of the research. At the FBS annual symposium, which attracts over 250 staff and postgraduates, PGRs present a “three minute thesis” (year 1), posters (year 2) or talks (year 3).

PGRs are encouraged to apply for their own grant and travel awards for national and international conferences, put forward for prizes and fully involved in many outreach activities (**Table 3**).

Activity	Examples
Grants and travel awards	Research internships at Universities of Auckland (x2), Bordeaux (x3), Vrije, Dresden Numerous travel awards from learned societies
Prizes	Many prizes for best oral communication TPS, ACSM, Romaine Harvey prize for best Biomedical Sciences thesis (last 3 winners from this UOA); £1000 grant at Europhysiology for a Kickstarter competition
Positions of responsibility	Affiliate Trustee, Committee for Professional Opportunities for Women, Central team member for the Yorkshire and Humber Physical Activity Knowledge Exchange, FBS Ethics committee, Engagement Excellence Fellow
Outreach	Discovery Zone, Pint of Science, Physiology Friday, Great Yorkshire Show, Be Curious, taster lectures

Table 3 Examples of PGR achievements

3. Income, infrastructure and facilities

3.1 Income

Our research benefited from 80 successful awards to academics from this UOA totalling £9.7 M in the REF period. Of these awards, 51% came from Research Councils (e.g. BBSRC, MRC, NIHR, UKRI, including those part-funded with industry), 40% from charities (e.g. BHF, ISRT, Wings for Life, Dunhill Medical Trust), and 5% from other sources, such as Leeds City Council, Sport England, Northern Ballet. Support for research grant applications and management of existing awards is provided through the Faculty Research Office, and the University Research and Innovation Service. Staff receive support to develop successful applications through local mock funding panels and a peer-led ECR group. Interview practice is given by local expert groups and by external professionals for fellowship interviews, which is especially relevant for ensuring inclusivity in obtaining grant income. This supportive environment has clearly enhanced application success, with the annual award value in the last three years averaging 75% increase in annual award value in the first three years of the REF period (compared to a UoL increase of 37%) and a 51% increase in research expenditure. Furthermore, MRC funding has more than doubled since REF 2014. Many awards incorporated a clinical collaboration and 23% of awards involved research using human subjects or patient groups. Formation of a new Patient, Public Involvement and Engagement (PPIE) forum, where patients contribute to research direction and experimental design, has enhanced patient-centred research. Our 80 grants demonstrate our continued success in interdisciplinary research, with 49% co-funded with other UOAs, including collaborative grants with Arts, Humanities and Cultures. Our strength in establishing novel interdisciplinary biomedical and related research is further supported by The Wellcome Trust Institutional Strategic Support Fund.

Funding highlights for CEP group include: 1) BHF Programme Grant (2016-2021), a 5-year continuation of a previous BHF Programme Grant, addressing the role of the Epac branch of the β -adrenergic pathway in physiological cell signalling and in pathology; 2) MRC New Investigator Grant to investigate signalling for muscle atrophy, mitochondrial dysfunction, and insulin resistance in heart failure and diabetes (**Bowen**); 3) BHF grant investigating factors limiting exercise tolerance in people with heart failure (**Ferguson**); 4) MRC CDA award (recently funded **Colman**) investigating remodelling of structure-function relationships underlying cardiac dysfunction in ageing and heart failure.

Funding highlights for BTE group, include: 1) BBSRC grant to develop a new framework for computational biomechanical models and 3Rs in musculoskeletal research (**Askew**); 2) Royal Society Research Fellowship to characterise the biomechanics of the insect flight motor (**Walker**).

The MCEP group has significantly increased research support from a range of funding agencies including: 1) International Spinal Research Trust grant on combining transcutaneous stimulation with functional practice to drive recovery of upper limb function in human spinal cord injury (**Ichiyama**); 2) Marie-Curie EU Fellowship on neural and behavioural mechanisms of active multisensory decision making (**Delis**); 3) Cancer Research UK grant on physical activity and cancer prevention (**Burke**); 4) Sport England grant on the development of a 'Dance Activator Programme' to increase physical activity levels in older women (**Astill**).

3.2 Infrastructure and Facilities

UOA24 concentrates research activities within physically-connected buildings, promoting collaboration by allowing research groups to share laboratory space and facilities. Our purpose-built laboratories are adjacent to the Leeds General Infirmary (LGI) and University Fitness, Sports and Wellbeing Complex providing excellent patient access and further promoting cross-faculty collaborations in sports and exercise focused research activities. We encourage sharing or donation of equipment and tissue to maximise research capabilities. The Garstang building, which houses the majority of our academics, is undergoing a further £32.25M refurbishment scheme to broaden collaborative research while facilities were boosted by £17M investment from the UoL. We provide 'well found labs' through an annual fund for maintenance and purchase of essential equipment, ensuring basic infrastructure and research facilities.

Academics benefit from institutional and external investments to extend and improve our research facilities that facilitate collaboration. For collection of preliminary data for grant applications, facilities are provided to staff at no or low cost. Research facilities are managed by the Head of FBS Research Facilities (0.6 FTE, new position). Relevant equality and diversity issues are addressed for access to facilities, e.g. a recent visiting researcher with physical disabilities participated fully in electrophysiological experiments.

The state-of-art communal exercise science facilities include 2 movement analysis laboratories, 3 exercise physiology laboratories, and an environmental chamber. Equipment enables 3D motion analysis and eye tracking, electromyography, tissue oxygenation, blood gas, electrolyte and acid-base blood analysis. There is also a range of ergometry equipment including 3 Lode Excalibur Sport electromagnetically-braked cycle ergometers, Biodex and Lode isokinetic dynamometry systems, recumbent ergometry, arm cranking dynamometry and an iDXA body composition/bone density scanner. We have recently invested in additional specialist research laboratories including those for human spinal cord injury research. The facility has supported REF outputs (e.g. **UOA24-4441, UOA24-1385, UOA24-1579, UOA24-1566, UOA24-1567, UOA24-1568**) and enabled collaborative research with GB Rowing and GB cycling. In addition, elite athletes, including Olympic and World Championship medallists have benefitted from performance analysis through this facility.

Use of multi-species facilities for small and large animals contributes to over 30 of the returned outputs. It has well-equipped surgical suites, behavioural analysis rooms, Category II work and flexible space to meet academics' research needs. A new wind tunnel facility enables research into muscle performance and fatigue to support recent grants (BBSRC). The facility now includes a software-driven animal locomotion analysis system for characterisation of spontaneous running performance in rodents (**UOA24-474**).

The Integrated Bioimaging Facility provides high resolution imaging of biological samples and is located in a purpose-built suite. The facility comprises high-resolution microscopes including two LSM880 instruments with fast Airyscan technology and a Delta Vision Deconvolution system allowing multicolour automated imaging of live (**UOA24-504**) and fixed cells over extended time periods. Super-resolution microscopy is provided by expansion microscopy and 3D PALM/STORM (photoactivatable light microscopy/stochastic optical reconstruction microscopy) (**UOA24-3234, UOA24-216**). Two epi-fluorescence microscopes equipped with colour CCD cameras provide general fluorescence and histology imaging and an automated multicolour slide scanner enables high content imaging (**UOA24-505, UOA24-504, UOA24-2076, UOA24-674, UOA24-672**). Academics have also benefitted from strategic University investment (part of the £17M above) in the Electron Microscopy Facility from the University (**UOA24-505, UOA24-675**).

Other new innovations include high speed camera systems for analysis of *in situ* muscle performance (**UOA24-3747**), EEG (**UOA24-3832, UOA24-4482**), transcutaneous magnetic stimulation, wearable technology to enable on-field data collection (**Tierney**) and implantable muscle stimulators for skeletal muscle angiotherapy (**UOA24-2817**).

Since 2014, the UoL has invested >£2M alongside £1.9M from The BHF in the development of a new centre for translational cardiovascular imaging (**UOA24-1566, UOA24-1567, UOA24-2176**), which incorporates cutting-edge multimodality imaging platforms such as a 7 Tesla MR system, a PET/SPECT/CT scanner, μ CT and optical imaging to enhance cardiovascular and biomedical research. The Clinical Research Facility is also used for measurements of human cardiovascular (**UOA24-2179, UOA24-673, UOA24-1567, UOA24-2176**) and pulmonary function (**UOA24-3492**).

3.3 Support for Research and Impact

Support for administration of research and innovation applications and awards is through the FBS Research and Innovation Office (6.6FTE). University research systems provide a streamlined "pre-application to post-publication and impact" environment, which supports all staff. The grant team supports costing of applications, provides advice on funders' rules and helps navigate application

systems, liaising with the contracts team for collaboration and funding agreement sign off. In addition, they provide financial support for live awards tracking available funds, identifying overspends or ineligible costs, and submit financial reports to funders. Together with the University-level Research and Innovation Services (RIS), they also support service and consultancy activities. RIS provides a central research development team with a dedicated RIDM, who supports over-lapping activities between UOAs including visits from Research Councils, contracts and commercial services such as development of patents and funding of early translational work. Other staff (3.3FTE) provide administrative assistance and secretarial support to the research groups e.g. seminar programmes, internal peer review, open access, REF, summer research studentships. The office also advises on publication destinations, deposition of published manuscripts in open access repositories and ensures maximum availability and visibility of our outputs. We are over 90% compliant with open access.

Three dedicated Health and Safety staff provide induction training, assistance with COSHH, etc. The Human Resources Office assist with staff recruitment, review and development, monitoring of probation etc. The University Procurement Office administers research purchasing, including assistance with tendering processes and acquisition of high value equipment. There is also an Operational Procurement team to support day-to-day acquisitions of lower value supplies and services. Computing software and hardware is purchased, installed and maintained by the University IT Service. A centrally organised team of technical assistants (6.5FTE) provide general research laboratory requirements and maintenance.

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

Despite many staff considered at early career stage, (61% of staff under 50), academics contribute extensively to the research base and society, reflected in the mention of all academics in this section. Our research involves extensive and productive collaborations across UoL for grant applications and research outputs. To facilitate these interactions, we organise cross-faculty conferences, to show-case techniques and opportunities. These lead to smaller, focussed meetings to build on identified strengths.

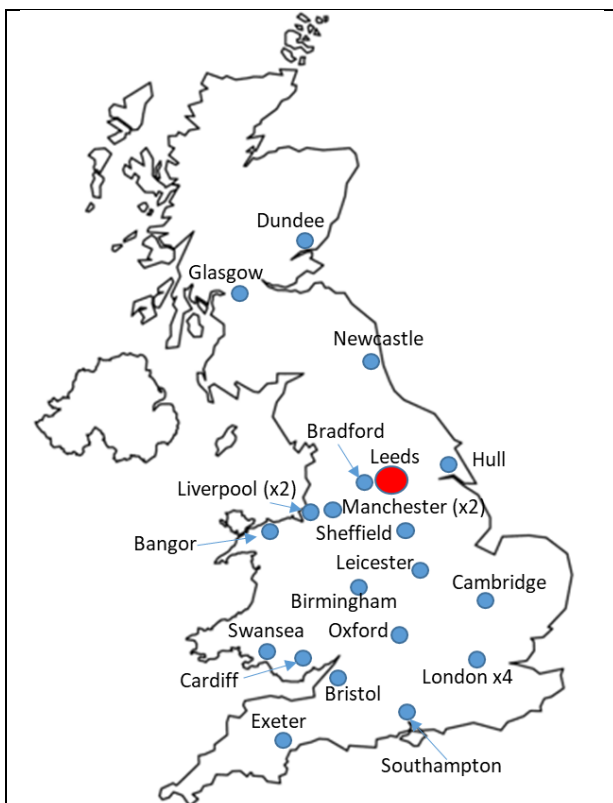


Figure 2 Map of the UK with cities showing established collaborations

We have **widespread national (24 institutions) and international (30 countries) academic collaborations** contributing to top quality research and impact (**Figures 2, 3, Table 4**). These include Zurich and Irvine (both ISRT); Mayo Clinic and Louisville (both NIH), Karolinska Institute (BHF) and University of Sao Paulo (Brazilian government funded); all contributing outputs. There are collaborative grants with University of Auckland (**White** EU Marie Curie grant), University of Montpellier (**Steele** BHF programme grant), while **Colman** (Barcelona Tech) is part of an international consortium modelling calcium dynamics. Many of these are critical for the collaboration and impacts discussed below.

We interact with NHS Trusts across the UK and **over 25 world-wide health sector partners** including The British Menopause Society, Wilhelmina Children's Hospital (Utrecht), Leeds Public Health and Age UK. We have ongoing collaborations with NATO (**Walker**), The Arts Council and Northern Ballet (**Astill**). We deliver bespoke packages of expertise for external clients, including methods of inducing and

measuring behavioural change, technology to measure movement e.g. wireless sensors for in-home assessment of elderly inactivity, dietetic advice to overcome malnutrition in older adults, community engagement with physical activity and long-term management of projects. **Burke** is developing a physical activity information book for palliative patients.

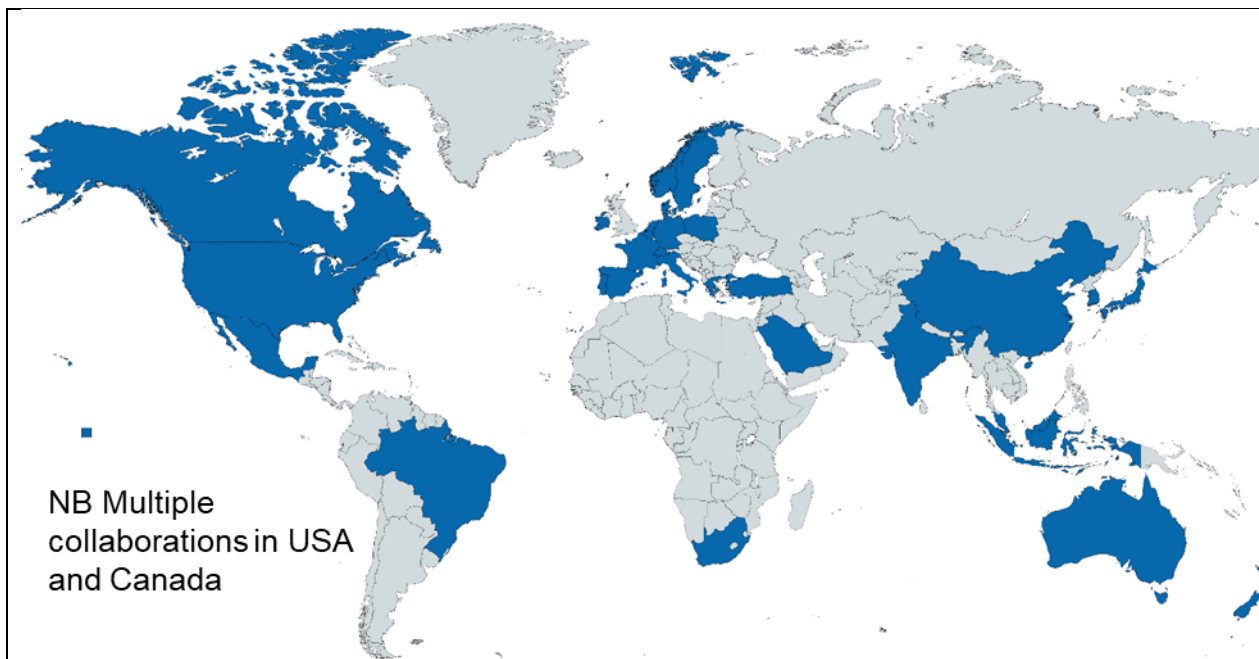


Figure 3 World Map showing international collaborations

Economic, Commercial, and Organisational Collaboration and Impacts.

We exploit our expertise and research findings by interacting with industrial partners to develop new products, such as innovations in treatment, ways of assessing patient or subject outcomes after new interventions, research tools or materials [UOA24-1-3]. Work with a number of companies, such as **AstraZeneca**, **GSK**, and **Boehringer Ingelheim** enables studies of sponsor-developed investigational products and researcher developed (**Rossiter**) exercise based outcomes in COPD patients. **Bowen** collaborates with companies such as **Myomedix** (Germany) and **Bienta**, Enamine (Ukraine) related to developing drugs (small-molecule inhibitors) to prevent muscle wasting in health and disease. He is a member of the current Leducq Foundation International Network grant (US-EU, 8 groups, £5M project) to develop drugs to overcome myopathies. **Berry** is working with industrial collaborators (JenaValve Technology, USA and Novasterilis, USA) on biomaterials for transcatheter aortic valve replacements and supercritical fluid sterilisation methods.

New collaborative ventures with an NHS-facing AI company and Seacroft Reproductive Services are in development, to assess the impact of engagement with mobile phone-based AI on uptake of exercise to enhance fertility (**Birch**). **Tierney** is working with Prevent Biometrics and Markers Diagnostics Ltd to develop technology for concussion prediction in contact sports. **Badrilla Ltd** (CEO **Colyer**) develops new imaging probes for DNA-PAINT microscopy and modelling for Western blot normalisation (**Colman**), and has licensed research tools, generating licence fee income. Tools are sold internationally to academic and commercial biomedical organisations, underpin 210 papers in REF period and generate R&D employment for 10 people

4.1 Collaborations Leading to Impacts on Health and Welfare.

Academics and clinical collaborations are critical to increase the impact of our work. Our research has driven changes in diagnoses and treatments and demonstrates health benefits of maintaining fitness and activity. Research findings are translated into products, guides for clinical rehabilitation and positive outcomes in pathological conditions or injury [UOA24-1,3]. **Bowen** is working with clinicians at LGI and UCLA to develop novel non-invasive exercise tests in humans to improve

stratification of disease severity in heart failure patients. This was followed by invasive measurements to confirm the mechanistic basis of exercise responses amongst hundreds of heart failure patients. This will inform development of new guidelines for exercise testing. **Edwards** is working with NHS Blood and Transplant on the Optimising Knee Therapies project to develop new human tissue products for use in the UK. **Rossiter** contributed to the European Respiratory Society guidelines for using exercise as an outcome to assess treatment efficacy in patients with pulmonary diseases. **Witte** contributed to the Canadian Cardiovascular Society guidelines on cardiac pacing for the management of heart failure. **Egginton** was part of a team that informed management of clinical ischaemia based on models of impaired hindlimb blood flow. **Bowen** contributed to position statements for governing organisations, such as European Society of Cardiology, on how exercise is a beneficial treatment for human health and disease and is selected to join European Association of Preventive Cardiology (EAPC) committee (Secondary Prevention and Rehabilitation). In collaboration with the University of Glasgow, **Delis** is studying the neural basis of decision-making deficits in dyslexia. **Birch** worked with Leeds Community Healthcare Trust to assess physiological benefits of cardiac rehabilitation in patients following cardiac events/interventions. The findings of low dose physical activity are spearheading discussion of failures to implement rehabilitation prescriptions. In collaboration with Bumps and Babies in Leeds, **Nykjaer** demonstrated that 12 week community-based physical activity interventions in pregnant and postnatal women increased physical activity patterns and mental wellbeing. **Tierney's** research into concussion risk factors in rugby featured heavily in pioneering legislative changes surrounding the tackle. He now works closely with national and international governing bodies for rugby league and union, providing expertise on injury biomechanics and with the Football Association to reduce the forces involved in football heading. He was appointed as an Expert Witness in Biomechanics for the legal team representing 100+ retired rugby athletes in the legal case against several national governing bodies

4.2 Collaborations leading to impact on practitioners and professional services.

Academics develop new clinical diagnostic tests, provide information for practitioners and establish ways to improve research models and outcomes from original research observations. Research regarding the impact of exercise on statin myopathy (**UOA24-474**) included 'Clinical Competencies', for healthcare professionals, describing how moderate exercise can be used to reverse detrimental effects of statins on muscle. **Egginton** developed a user-friendly, public domain series of analytical tools to assess muscle phenotype and impact of tissue oxygenation from biopsy samples, providing a high-throughput option permitting diagnostic investigations in human and animal samples. **Ichiyama** works with the RSPCA, researchers and veterinarians, on refinement of rodent models of spinal cord injury. **Deuchars** co-organised an international Joint Physiological Society/Intensive Care Society Covid-19 conference, considering lessons learned by clinicians and researchers.

4.3 Collaborations leading to impacts on public policy, research environments and education.

Academics provide research-based evidence for public policy and educational bodies via involvement in the development of training materials, expert reviews, and external advisory visits. **Ichiyama** addressed the House of Lords on the importance of spinal cord injury research in the UK. **Astill/Burke** work with Yorkshire Dance on an Arts Council funded project, looking at the benefits of dance for children from deprived areas in Leeds and for children and young adults in Leeds, Rotterdam, and Madrid. **Astill** actively engages with Yorkshire & Humber Physical Activity Knowledge Exchange. **Rossiter** is a member of The Chronic Obstructive Pulmonary Disease Biomarkers Qualification Consortium, an international industry-academic-regulatory authority-foundation collaboration to qualify new outcomes as targets for therapy. **Bowen** was involved in the production of European Society of Cardiology position statements on exercise training to prevent and treat cardiovascular diseases.

4.4 Promotion and dissemination of research and impact

The University Communications and Press Office achieve promotion and dissemination of research and impact beyond traditional academic routes. These provided widespread media coverage (we average 24 releases per year with several hundred international 'hits'; **Table 4**).

Academics play active role in patient, public involvement and engagement. Examples include: **Ferguson** to Heart Support Groups and targeted public engagement talks; **Rossiter** to numerous groups (e.g. PEP Pioneers) on the importance of exercise on pulmonary rehabilitation; **Ichiyama** speaking on spinal cord injury research to stakeholders including people with SCI, carers, donors, charities, politicians and the general public. Many academics give public lectures or exhibitions (**Table 4**). The Discovery Zone (**Deuchars**) has enabled over 5000 schoolchildren to experience hands-on scientific activities. These include healthy hearts, dangers of sedentary living and analysing muscle activity, staffed by PDRAs, PGRs and academics from UOA24.

4.5 Other contributions to the discipline

Academics contribute substantially to the wider research base (**Table 4**), acting as editorial board members or as associate editors on many journals and work as reviewers for an incredibly diverse range of over 70 journals. Academics also serve on grant panels such as BHF, BBSRC, NIH and review grants for a range of national and international funding bodies including MRC, BHF, BBSRC, Wellcome Trust, NSF, NIH.

Many academics are actively involved in learned societies. **Deuchars** chairs Conferences Committee for The Physiological Society. **Egginton** was president of the British Microcirculation Society. **Rossiter** sits on the science policy committee for the American Physiological Society. We take an active role in organising workshops and conferences that enhance dissemination of our research and provide professional training. **Bowen** co-ordinated a British Council funded international workshop tackling world health and humanitarian issues related to gunshot wounds and rehabilitation. **Ferguson/Rossiter** delivered a professional development workshop on cardiopulmonary exercise testing to over 20 International delegates. Academics are active in professional scientific organisations such as the International Society for Motor Control, National Association Sport Physical Education and BASES and maintain a wide range of knowledge transfer activities.

Table 4 – contributions to the discipline

Type of contribution	Selected Examples
National and international advisory boards	BHF (White (vice-chair Fellowships committee), Calaghan, Lancaster), BBSRC (Askew) Danish Council for independent research (Egginton), International Spinal Research Trust (Ichiyama), NY State Department of Health and Spinal Cord Injury Research Program (Ichiyama), European Society of Cardiology (Bowen), European Respiratory Society (Rossiter), COPD Biomarker Qualification Consortium (Rossiter), International Research Council on Biomechanics of Injury (Tierney), National Institute of Health Research (Birch), Irish Health Research Board (Berry)
Society Trustee/Committee member	The Physiological Society (Egginton, Deuchars), Society for Experimental Biology (Askew), American Physiological Society (Rossiter), British Association of Sport and Exercise Medicine (Egginton), Society for Qualitative Research in Sport and Exercise (Burke)

Editorial board membership	Editorial boards: Biology Letters (Askew), Experimental Physiology (Rossiter), Microcirculation (Egginton), Psychology of Sport and Exercise (Burke), Translational Sports Medicine (Egginton), Cardiovascular Research (Steele), Scientific Reports (Delis), Frontiers (Ichiyama) Associate Editor: Research Quarterly for Sport and Exercise (Burke), Autonomic Neuroscience: Basic and Clinical (Deuchars), Journal of Cachexia, Sarcopenia and Muscle (Bowen)
Invited speaker (international)	Society for Experimental Biology (Egginton) World Congress of Biomechanics (Askew) IUPS (Deuchars) Spinal Research Network Meeting (Ichiyama) Australian Physiological Society (White)
Organiser of an international conference	Europhysiology 2018 - Chair of programme committee (Deuchars) World Congress of Microcirculation, Vancouver (Egginton) World Congress of Biomechanics (Askew) International Brain Research Organization (Ichiyama)
Visiting lectureship/chair	Covance (Colyer), SISSA, Italy (Ichiyama), Bordeaux (White), UCLA (Rossiter), Athens (Delis)
Prizes and esteem factors	Antarctic Service Medal of the USA (Egginton), Fellowship of Physiological Society (Egginton, Rossiter), Young Investigator Award, Computing in Cardiology (Colman), Royal Society University Research Fellowship (Walker), Fellow of ACSM (Birch, Rossiter), Chair of UK Neuromodulation Network (Ichiyama)
External examining (UG and PG)	Over 40 institutions including: UCL, Oxford, Dublin, Glasgow, New Zealand, Australia, France, Denmark, Cape Town
Promotion and dissemination of impact	BBCTV, Sky News BBC World Service, Radio China Discover Magazine, Science Magazine, Chemistry World Guardian, Telegraph, Times, New York Times, Observer, Daily Mail, MSN, Economist Pint of Science, Café Scientifique, Be Curious, STEM Ambassador, Physiology Friday, TEDx, School talks