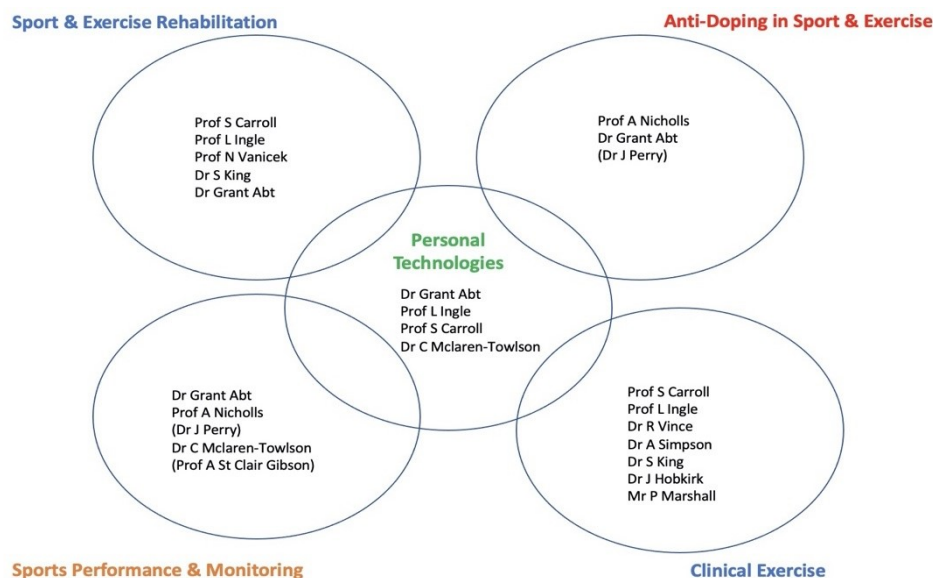


Institution: University of Hull
Unit of Assessment: 24 - Sport and Exercise Sciences, Leisure and Tourism
<p>Unit context and structure, research and impact strategy</p> <p>Summary:</p> <p>The University of Hull (UoH) has increased its support for multidisciplinary and translational research within sport, exercise, and related healthcare research, through substantial investment in staff and infrastructure. The University has undergone a major re-organisation and all healthcare-related research, including Biomedical Science, Medicine, Psychology, and Sport, Health & Exercise Science (SHES), all now located within the Faculty of Health Sciences (FHS; August 2017). This re-organisation has strengthened existing collaborations between UoA24 staff and other areas and facilitated strategic investment in a number of new cross-cutting initiatives, for example the Institute for Clinical and Applied Health Research (ICAHR). A strength of sport and exercise science research (UoA24) in Hull is the close working relationships across the health professions involving staff at both the University and The Hull University Teaching Hospitals (HUTH) NHS Trust. Cross-institution collaboration also includes longstanding relationships with elite sporting organisations across the region, especially professional rugby league and association football in the city. This close partnership benefits SHES research at all levels and facilitates translation into practice for both clinical patient benefit and sporting-related outcomes.</p> <p>The UoA24 submission comprises 12 members of staff (11.6 FTE; 22.4 % female / 77.6 % male; 10.6 SHES staff; 1.0 FHS Associate Dean Research). This REF period has seen the further development of UoA24 research leaders at the UoH (4 Professorial and 1 Readership) and early career research (ECR) staff appointments. There has been continued investment and development of extensive research facilities, together with the widening of the scope and impact of important regional and worldwide multi-disciplinary research collaborations. This has secured a strong pathway for the development of nationally and internationally recognised impactful research.</p> <p>The UoA24 shows substantial improvement in independent research income from various sources, including competitive international sporting organisations and NHS Research funding streams. Total (all years) research income has increased progressively from 89.9 K (RAE2008) to 270.0 K (REF2014); to over 937.0 K in REF2021; with an associated grant award level of over 1.5 million in this period. UoA24 research income (per FTE, per year), has increased from 4.92K (REF2014) to 11.6K (REF2021). Furthermore, there has been significant external grant income success as part of University consortia and larger-scale international research collaborations. Such partnerships have resulted in a substantial improvement in research capacity and capability and are evidenced by high-quality research outputs. Historically, doctoral student awards were above sector norms (REF2014) and have further increased from 0.29 per staff FTE per year (REF2014) to 0.32 in the current period. The UoA24 research remains primarily applied and multi-disciplinary in its overall orientation within the sport and exercise sciences, and increasingly influential in its capacity to impact on clinical and community health-related exercise settings regionally. The research also impacts on elite sporting organisations regionally and globally, multi-centre national and European trials of healthcare and sporting interventions, and to inform on specific healthcare and sport-related guidelines.</p> <p>Unit context and structure, research and impact strategy:</p> <p>Sport and exercise science research at the UoH can be broadly classified under 5 thematic areas (see Figure 1). As shown, several senior staff contribute to more than one thematic area. Each area is led by at least one senior staff member with established publication record and research income, and these provide a vibrant research environment in which ECR and postgraduate students are trained in critical evaluation skills, cutting-edge technologies and research and methodological skills relevant to their area of investigation. Core equipment and seminar series</p>

are shared across the disciplinary subjects at SHES departmental and the FHS level, with staff and students being actively encouraged to research across the interdisciplinary boundaries.

Figure 1. Overview of the sport and exercise science research clusters (UoA24) at University of Hull



1. Sport and Exercise Rehabilitation. This multi-disciplinary theme has focused intensively on exercise-based rehabilitation for patients with chronic disease conditions/comorbidities, including cardiovascular disease and chronic heart failure phenotypes, peripheral vascular disease with intermittent claudication, older postmenopausal women with osteoporosis, and lower limb amputees (LLA) (Impact case study on LLA). This research area led by Professors **Ingle**, **Vanicek** and **Carroll**, has distinct and direct relevance to contemporary clinical practice and health service development in exercise rehabilitation. Research within these areas incorporates quantitative, qualitative and mixed methodologies and UoA24 staff work in collaboration with NHS service providers, including the vascular laboratory at Hull Royal Infirmary (Chetter and colleagues), City Healthcare Partnership, Hull (Cardiovascular and Pulmonary Rehabilitation) and different NHS multi-disciplinary care teams supervising patients following both traumatic brain-injury and lower limb amputation. In collaboration with the City Healthcare Partnership, Hull, cardiac rehabilitation exercise classes have been delivered/researched from SHES and contribute to the regional coverage by NHS clinically supervised, structured exercise classes for individuals recovering from cardiac events. Prosthetics services within the NHS are an under-researched area, especially in relation to provision for older and below-knee amputees. **Vanicek** and colleagues (Hull & East Riding multidisciplinary healthcare team in prosthetics rehabilitation led by Salawu, HUTH NHS Trust) have recently established the 'KEEP MOVING' (KM) supervised exercise programme at the Allam Sport Centre, UoH. This provides specialist exercise rehabilitation, health and well-being for clinician referred amputees living within the community. This multi-component programme designed and developed with evidence-based biomechanical improvements in gait parameters, falls reduction and quality of life outcomes. Funded by the NIHR (Research for Patient Benefit), Vanicek and multi-disciplinary colleagues (consultants, prosthetists, physiotherapists) have demonstrated the feasibility for a large national, multicentre, trial investigating effectiveness (patient benefit and cost implications) of a novel prosthesis compared to standard treatment (Stepforward Study). **King's** complimentary research expertise in the biomechanics of gait/movement patterns of vascular disorders and the impact of routine NHS-delivered exercise interventions can have on these movements, physical function and balance (and the musculoskeletal system).

2. Clinical Exercise Science. Staff in this thematic area have developed on the work submitted to REF2014, investigating the mechanisms and adaptations to acute and chronic exercise interventions in a range of primary and secondary settings, including obesity, polycystic ovarian syndrome, Type 2 diabetes and following a cardiovascular or cancer diagnosis collaborating with HUTH and Leeds University Teaching Hospitals NHS Trusts. Staff in UoA24 have longstanding involvement with the Centre for Cardiovascular and Metabolic Disease (CCMR), HYMS. This wider university cluster aims to increase our understanding of molecular and cellular mechanisms responsible for development of disease, and translate these findings into clinical benefits. This innovative work tackles major global health challenges that have significance locally. This facilitates direct access to relevant patient cohorts required for UoH translational research programmes. **Vince, Carroll** and **Hobkirk** have worked closely with the CCMR (especially Sathyapalan and colleagues), researching the effects of exercise and lifestyle interventions on adiposity, insulin resistance and associated metabolic disorders. Research in this area has been bolstered by a generous philanthropic gift of £8 million from Dr Assam Allam (an alumnus of the University and highly successful local businessman) to establish a new Diabetes Centre based on local clinical requirements but underpinned by a cutting-edge research programme. Collaborative work has been undertaken on collective areas of interest, including the modulation of cardiovascular risk through both pharmacological and nutritional/exercise-based interventions in diabetes, PCOS, obesity and metabolism. Notably, UoA24 staff have collaborated on investigations of the effects of exercise training on lipid-induced insulin resistance and the effects of standard diabetic medications (statins and metformin) on aspects of lipolysis, endothelial and inflammatory responses.

3. Personal Technologies in the Sport and Exercise Sciences.

Led by Reader **Abt**, this new interdisciplinary research group has been established to understand how wearable personal technologies, such as smartwatches, can influence physical activity behaviours and clinical exercise prescription, as one component of a multifactorial solution to the physical inactivity crisis affecting health and disease states. This group have conducted a range of fundamental studies on the validity and reliability of key personal technology devices in apparently healthy adults, as well as the setting of cardiovascular rehabilitation (and interfacing with the other thematic areas). This group will continue their work on understanding the measurement capabilities of wearable devices, including the development of innovative applications for improving the accuracy of measurement and behaviour change. For example, a novel Apple Watch app ('MVPA') has recently been funded through the Higher Education Innovation Fund (HEIF).

4. Sports Performance and Monitoring.

This group is developing an international research profile focused tightly on performance and physiological responses to intermittent exercise, including methods of individual player monitoring and match analysis, especially within elite rugby league and association football. The group has also focused on the effect of biological maturity on sports performance, and player selection and development within elite football academies. This research (led **McLaren-Towlson**) has recently been funded by UEFA, the governing body of football in Europe. With external collaborators (Weaving and others, Leeds Beckett), **Abt** and colleagues have published widely on improving multivariate data monitoring and quantification of internal and external sporting training loads. The collaboration has made recommendations for commercial companies to improve their sporting/athlete monitoring software platforms by "combining" unique aspects of information provided by multiple training-related variables. Future research using multivariate approaches will further develop knowledge of the dose-response nature of training load monitoring with potentially important outcomes, such as changes in fitness, performance, and injury risk. Group members also contribute to internationally collaborative research on the interdisciplinary understanding of fatigue-related processes (**St. Clair Gibson**), including cerebral regulation during maximal exercise. Other group members research the influence of psychological stress and coping as a mechanism of enhancing performance (**Nicholls**).

5. Anti-doping in sport and Exercise.

Doping practices represent a significant threat to the fairness and the physical and mental health of all sports performers and athletes. Led by **Nicholls**, researchers have rapidly established themselves as leaders in the area of anti-doping educational programmes. This includes creating the first measurement tool to assess adolescents and the development of a series of alternative approaches to complement traditional anti-doping testing programmes. UoA24 staff have devised innovative education programmes designed to lessen athlete doping susceptibility and reduce the likelihood of coaches recommending banned substances to their athletes. The development and validation of the Adolescent Sport Doping Inventory (ASDI), and the implementation of acclaimed novel educational programmes for young high-level athletes (iPlayClean) and grassroots coaches (Anti-Doping Values in Coach Education; (ADVICE)) to reduce favourable doping attitudes have been key outcomes of the group. This internationally recognised research has been supported by competitive funding from the International Olympic Committee (IOC), the World Anti-Doping Agency (WADA), and the European Commission and there are continuing collaborations with numerous national anti-doping organisations across Europe.

Research & Impact Strategy

Sport and Exercise Sciences, Leisure and Tourism was identified as the most improved UoA within the UoH in RAE2014. The University has continued investing in multidisciplinary, translational health research with the aim of delivering world-class research that benefits patients and the wider population. The major reorganisation of the University, as described above, has significantly strengthened the focus and multidisciplinary nature of SHES research within a broader Faculty-wide approach. Psychological well-being, cancer, chronic cardiovascular disease, Type 2 diabetes and obesity with their associated disorders remain some of the major health issues facing society and are highly endemic within the city of Hull. Researchers at Hull, in collaboration with academics around the world and in partnership with patients, user groups and commercial entities have continued to work closely with clinicians from the local NHS Trusts (Primary and Acute) in developing successful research programmes leading to improvements in knowledge and patient care.

UoH is committed to promoting equality of opportunity for all, giving every individual the chance to achieve their potential, free from prejudice and discrimination. The University's Equality Scheme was published in 2017, and in the same year the University committed to 'Disability Confident'. There is an active LGBT Staff Network, which advises, and responds to, the University's position in this context. It is the University's aim to use its staff's diverse backgrounds to enhance professional knowledge and bring challenge and new perspectives to all that is done on campus. The goal is to build capability and support for our students and staff. UoH is an organisation that embraces equality, diversity and inclusion as we believe this will deliver better results and greater innovation, more motivated staff, and increased recognition from our partner organisations. The UoH is committed to:

- Treating all staff and students fairly;
- Creating an inclusive culture for all staff and students;
- Ensuring equal access to opportunities to enable students to fully participate in the learning process;
- Enabling all staff and students to develop to their full potential;
- Equipping staff and students with the skills to challenge inequality and discrimination in their work and study environment;
- Making certain that any learning materials do not discriminate against any individuals or groups;
- Ensuring policies, procedures and processes do not discriminate.

In addition to the above ethos, that is supported by relevant codes of practices and statutes, to support our commitment to equality of opportunity, the University has a network of staff as Dignity and Respect Advisors (DARAs) from a wide range of roles and departments. DARAs are approachable, independent, fully trained and ready to help all staff and visitors who may be experiencing problems with harassment and bullying, should it occur.

SHES have produced a 3-year research strategy document, that is reviewed annually at Faculty Research Committee. Research strategies include a SWOT analysis that includes equality and diversity and ECR. All new research staff are required to complete an online Research Integrity course, that covers all aspects of good practice, this must be redone on a 3-yearly basis.

Staff from UoA 24 collaborate actively with several areas within the FHS and the Institute for Clinical and Applied Health Research (ICAHR). The Institute is based in the new Allam Medical Building, opened by Her Majesty The Queen, in November 2017, which is at the heart of the University's £28-million investment in its Health campus. The Allam building has state-of-the-art teaching and research facilities, with more than 50 networked computers, bookable research rooms, and breakout space. The Institute encompasses the expertise of the Hull Health Trials Unit (HTTU) which leads and supports high quality clinical research studies, many of which are sponsored by the local NHS Trusts. The HTTU employs 8 high-specialist staff, including Information, Systems, Operations and Trials Managers, who deliver a range of practical and specialist support throughout the research process. The unit, which gained provisional registration to the UK Clinical Research Collaboration registered clinical trials unit network in 2019, provides regulatory compliant information systems which allow for the management of data, including data cleaning, exporting data for reporting and analysis. HTTU provides a data capture framework and offers the provision of safe and secure storage for datasets requiring compliance with NHS information governance toolkit standards. UoA24 staff have been supported by advice on appropriate funding sources, generating costing models, providing statistical expertise.

Research Seminar programmes

SHES hosts a UoA24-specific research seminar on a monthly basis. This seminar series has invited speakers from inside the unit, from other UK institutions, and from abroad. For example, in the last two years presentations have been delivered by:

- Dr Kate Button (Bath): Grassroots training for reproducible science
- Prof Tony Myers (Newman): An introduction to Bayesian data analysis
- Dr Ian Lahart (Wolverhampton): Exercise and cancer
- Dr Sean Cummings (Bath): Biological maturity in young athletes
- Dr Clym Stock-Williams (TNO, Netherlands): Machine learning: What is it and why should we care?

This seminar series is complemented by two multidisciplinary seminar programmes in Biomedical Science and ICAHR. Since 2011 the annual, endowed, FHS Allam lecture series has included prestigious speakers from across the breadth of medicine relevant to UoA24 and UoH wider research programmes. Below are examples of selected speakers;

- 2014 – Sir Magdi Yacoub, 'The glory and threat of science and medicine'
- 2016 – Professor Maria Belvisi, 'How the lung senses its environment'
- 2017 – Professor S Richard Underwood, 'Cardiac imaging: the next decade'
- 2018 – Professor Stephen Shalet, 'Cancer survivors: the new endocrine epidemic'

Strategic Aims and Goals 2021-2028

Our aims are to continue to produce high quality impactful research and develop and nurture the research leaders of the future. Specifically, during the next REF period we aim to focus on our areas of research strength, as outlined below;

- Sport anti-doping and educational initiatives.
- Developing and evaluating contemporary methods of delivering tailored exercise rehabilitation in clinical groups and examining their efficacy and effectiveness.
- Evaluating the role of personal technologies in providing personalised physical activity and exercise prescriptions and their contribution to adherence and compliance with evidence-based guidelines.
- Improving multivariate training-load monitoring measures in sporting contexts.
- Mentoring ECR and new interdisciplinary PhD clusters.
- Develop research partnerships via funded PhD clusters with Team GB (partner of the UoH) athletes, coaches, and sport scientists.

We will meet the aims identified above by increasing external grant funding in part through increased collaborative projects with commercial partners and an extended range of end-users.

People

The FHS research strategy is underpinned by investment in new appointments and facilities, with the explicit aim that staff are empowered to produce outputs of the highest quality and impact. All new appointments are placed in existing research teams, or where a new strategic area is created this will be led by a Chair appropriately supported by senior and junior academics. The UoA24 submission comprises 12 members of staff (11.6 FTE; 22.4 % female / 77.6 % male; 10.6 SHES staff; 1.0 FHS Associate Dean Research). Since 2014, several members of senior staff from within the UoA24 have been supported to attain professorial posts in SHES, including **Nicholls** (sport psychology), **Vanicek** (clinical biomechanics) and **Ingle** (clinical exercise physiology). **Abt** has also been promoted to Reader (sport & exercise physiology). **Matsakas** an ECR initially appointed within SHES, has been promoted internally to Senior Lecturer within HYMS. All early career staff members (ECR) in whichever academic discipline are supported extensively. Measures include the allocation of both research and teaching mentors, and support in joining PhD clusters to provide studentships, together with start-up funds to pump-prime research. Postgraduate students, postdoctoral researchers and ECR are explicitly encouraged to apply for FHS and UoH internal funding to facilitate research development (especially new initiatives by allowing research visits, conference attendance, purchase of small items of equipment, publication charges); also, opportunities for HEIF and other central funding sources.

SHES has been successful in recruiting promising ECRs; appointed on the basis of their existing high-quality outputs and their capacity to develop into strong independent researchers within areas that complement or bring additional strengths to the main research foci of both SHES and UoA24. In this period, ECR recruits include **Simpson** (in respiratory physiology), **King** (clinical exercise biomechanics) and **McClaren-Towlson** (developmental physiology/sports coaching). Overall, UoA24 submission shows a maturing of the academic staff profile with fewer ECR (from 45% of all submitted staff in REF2014).

The Research Funding Office supports these staff in applying to other sources of start-up funding. Plans for study leave of varying lengths (up to a semester every 3 years) are encouraged from all members of staff to ensure staff develop / remain abreast of advances in their field through collaborative networks of peers, industry and colleagues in practice.

During the 2018/2019 academic year the University initiated a Transformation programme, with a key component of this being a new academic careers' framework where all staff were aligned to one of 4 strands that best reflected their job role: Research, Teaching, Entrepreneur, or

Transitional. All staff on the Research domain had nominally at least 40% time for research in their workload, and all are returned under the relevant REF UoA24. The allocation to the most appropriate strand was done in consultation with the line manager and allowed all staff the opportunity to reflect on their current role and future career plans.

The University is fully committed to the principles of Athena SWAN and a steering committee, chaired by the Pro-Vice Chancellor (Research & Enterprise), oversees this and all staff development activities. UoH has a Bronze Athena Swan award. Plans are in place for the entire FHS, with the exception of HYMS, to submit an Athena Swan Bronze application in April 2022. In a similar manner that Athena Swan seeks to advance gender equality across all aspects of academia, the University recognises the need to value and enhance the career development of post-doctoral research scientists. A steering group, comprising representatives from all faculties, oversees the adoption of the Concordat supporting the Career Development of Researchers. Importantly this group has representation from the post-doctoral researcher community itself. The Faculty Ethics Committees (with SHES representatives) ensures that any research carried out by SHES staff or students meets the highest standards of ethical behaviour and report to the University Ethics Committee. Further, UoA24 staff have served as NHS LREC members. The UoH Learning and Development provides a series of comprehensive training packages for all new staff commencing with an induction course and personal/ professional development and upskilling for all academic staff; many courses are specific for the post-doctoral community, including research supervision. Staff research is actively monitored by Heads of Department as part of appraisal and development reviews.

UoA24 PhD student (FTE and headcounts) increased substantially during the 2008-13 period. Subsequently, doctoral degree headcounts of 19-25 students were attained in the years 2013/14 to 2016/7 (16 to 19.3 FTE). This postgraduate investment strategy included the continued departmental investment in Graduate Teaching Assistants (GTAs). Table 1 below summarises the UoA24 entire PGR community (students registered for a doctoral or other PGR degree); and PhD completions in the period. This summarises to an annual mean of 2.9 PGR students per SHES staff member (2.0 student FTE) over the period. In REF 2014, 16 research doctoral degrees were awarded (0.29 students per staff FTE). This has increased by approximately 21% to 26.7 PhD awards in the current period (0.33 students per staff FTE; REF 2021). Doctoral degree completions (per SHES staff FTE) were higher 0.36, excluding St Clair Gibson (the FHS ADR). Continued financial and academic investment is planned for PhD clusters in the next REF period, and there is an agreed strategy to focus on jointly funded PhDs with external partners to enhance the translational aspect of UoH's programme.

Table 1. PGR students in UoA24 2013/4 to 2019/20.

Year	PhD & other PGR (FTEs)	PhD & other PGR (Headcount)	Doctorate completions
2013/4	22.3	32	2
2014/5	25.3	38	2
2015/6	25.2	33	1
2016/7	20.3	28	8
2017/8	17.6	24	4.5
2018/9	17.7	33	3.2
2019/20	15.3	25	6

UoH has also changed the way it supports PhD studentships. In an effort to concentrate research and build critical mass in areas that align with the Institution's strengths, and its important local and regional role, the UoH has invested in a series of PhD studentships in healthcare. Since 2016, the Doctoral College, UoH has operated a competitive scheme to award inter-related PhD clusters. An internal competition is held, facilitated by external expert panel members, to select the best strategic fit projects and culminates in the award of 5 to 8 PhD clusters (3-6, fully-funded studentships and/or fee waivers) each year. Supervisory teams are required to be multidisciplinary and ideally cross-faculty in nature, to promote interdisciplinary. Students become embedded in

the relevant research groups contributing to the PhD cluster, and the cluster itself forms the nucleus of the multidisciplinary activity fostering new research ideas and funding, whilst benefiting from the existing research ethos in the various groups. UoA24 staff (**Abt** and **Ingle**) have attained institutional support for PhD clusters since 2014, including PhD students in ICAHR/HYMS. Other UoA staff comprise supervisory teams for medical doctorates within HYMS (**Carroll**, **Hobkirk** and **Vanicek**).

Importantly, within this REF period, UoA24 has benefitted considerably from the appointment of several postdoctoral research assistants (PDRA) (such as, **Hobkirk**, Nichols S, and Thompson). These PDRA posts represented a step-change in the research culture and capacity for the UoA and have typically been funded in partnership with other university research centres, external healthcare providers, or supported by external grant income.

Numerous SHES PhD graduates have, in this REF period, attained academic posts within HE institutions (examples include **McClaren-Towilson** and Bray both SHES, Hull); also Orange (Newcastle), Taylor (Leeds Beckett), Nichols, S (Sheffield Hallam) and Birkett (Central Lancashire), O'Doherty (Northumbria); others have secured research-based posts within regional clinical trials units (O'Carroll (Leeds) and Northgreaves (Hull Health Trials Unit). Giving postgraduates chances to network and present their data is considered an essential part of their training. Most PhD students have published articles in peer-reviewed journals and presented widely at national/international conferences (ECSS, ASCM) (for example Page, Birkett, O'Carroll, Scott, Orange). Impressive first and co-authored scientific outputs in higher-impact journals among several recently completed doctoral students (including former GTA's such as Nichols S, Orange, **McClaren-Towilson**, Taylor, Thompson, Weaving) are further testimony to a highly productive postgraduate environment. There is good evidence within REF2021 submitted outputs of ongoing collaboration between former postgraduate students and UoA staff. The development of postgraduate taught MSc degrees in Cardiovascular and Cancer Rehabilitation and Clinical Exercise Physiology (all with a 3-module research dissertation component) has contributed to a research culture within UoA24. For example, former MSc graduate Pymer is now a doctoral student within the Academic Vascular Surgery Unit, HYMS. These programmes have integrated well with the now established annual SHES undergraduate /postgraduate student thesis conference (supported by a University teaching and learning funding) and formed an important strategy of recruiting PhD and postgraduate researchers. The UoA often provides PhD fee waiver for its undergraduate students of distinction (for example, Gleadall-Siddal, Jackson, both PhD submissions within this REF cycle).

The University's Doctoral College is both the administrative centre for postgraduate research students and a purpose-built resource, with its own 24-hour access IT facilities and student common rooms. It oversees the monitoring of all research student progress and provides a range of administrative supportive structures, including supervising training to ensure successful PGR students. PhD students produce annual reviews at the end of year 1 and year 2, academics independent of the supervisory team contribute to an oral examination. Furthermore, the Faculty records the monthly supervisory meetings held between all postgraduate students and their supervisors (these are held at appropriate times for part-time students). If progress issues are raised by supervisors or students, the relevant departmental Postgraduate Research Director will attempt resolution.

Income, infrastructure and facilities

UoH receives approximately £7.5million in QR of which around £3.3million was allocated to the FHS. The Institution has taken the strategic decision to invest almost half its QR funding to support the aforementioned PhD/PDRA clusters, with the remaining funds to be used by Faculties to support new appointments and infrastructure. The University has invested in a significant refurbishment and redesign of the library (£27 million). In addition to dedicated PhD workspace within departmental facilities, there is increased access to fully networked computers and extensive journal collections, the majority of these being available online. The library is host to a

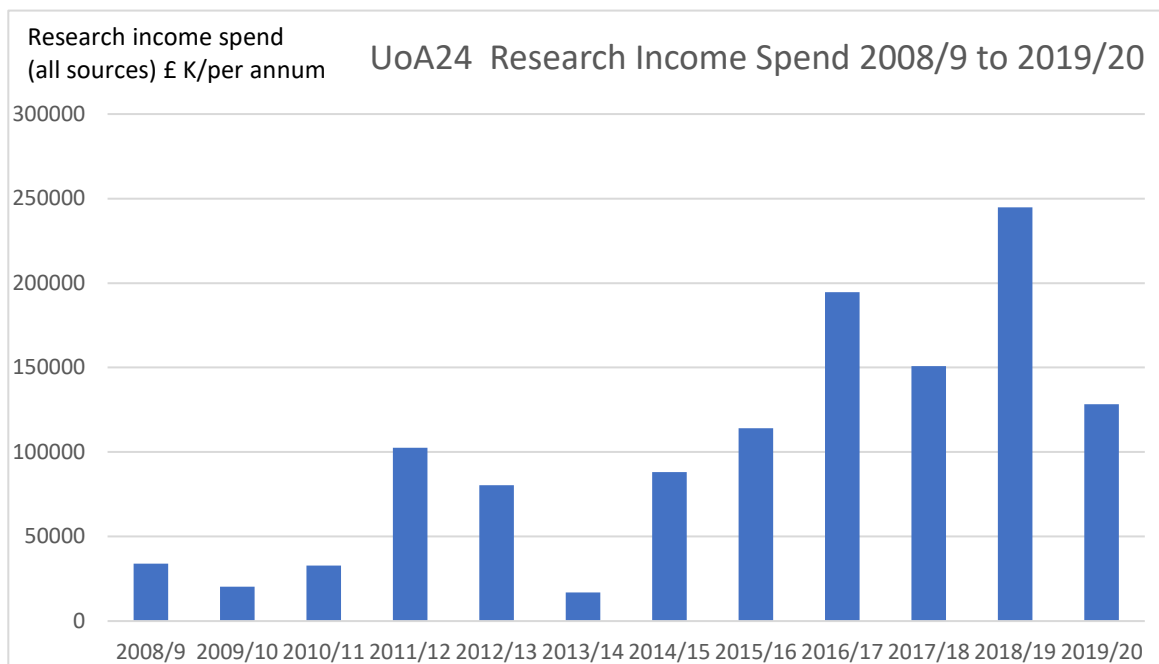
highly regarded art collection and regularly hosts cultural events, to which all PGR students have access.

The current UoA24 submission is returning 11.6 FTE staff which is consistent with the number in REF2014. However, the UoA24 has been able to demonstrate considerably more success in attracting higher levels of external funding from a range of sources. Notably, the total (all years) research income has increased substantially from 89.9K (RAE2008), 270.0K (REF2014) to 938.0 K (REF2020). There has been 1.5 million of grant income awards for UoA24 staff, as principal or co-investigator, within the REF2021 period. The very positive trends in research income spend over the last 2 REF cycles are illustrated below (Figure 2). Improved research income has been derived from significantly increased contribution from European Union Govt, UK Central/Local Govt, UK Charities (open competition), NIHR Research Funding (open competition as Project grants and Research for Patient benefit studies). Further, non-EU international sporting organisation grants, and local health charities and related sources are an emerging feature of an improved and expanding portfolio of external research.

Numerous prestigious awards achieved in the period are detailed below, and exemplify the breadth and nature of direct/collaborative awards to UoA24 staff;

- \$61, 193.09 : Nicholls et al. Development and validation of the Adolescent Sport Doping Inventory; 2014-2017; World Anti-Doping Agency.
- \$188, 719.00 : Nicholls et al. The Effectiveness of the Play Clean Group Based and the Mobile Application (iPlayClean) Anti-Doping Education Programs for High-Level Adolescent Athletes and their Entourage: A Randomised Control Trial. (July 2016- June 2019; International Olympic Committee.
- €487, 529.75: Nicholls et al. Anti-Doping Values in Coach Education (ADVICE); 2017-2019; European Commission: Education, Audiovisual and Culture Executive Agency [Unit A.6, Erasmus +: Sport, Youth and EU Aid Volunteers].
- \$22, 606.00 : Duncan, et al. Enhancing attention and recall of doping prevention messages by testing the influence of adolescent athletes' perceived vulnerability to doping; 2019–2019; World Anti-Doping Agency Social Science.
- £149, 291.64: Chetter et al. High Intensity Interval Training In pATiEnts with intermittent claudication (INITIATE): a proof-of-concept prospective cohort study to assess acceptability and clinical efficacy; 2019–2021; National Institute for Health Research.
- £249,000 Vanicek et al. Self-aligning prosthetic device for older patients with vascular-related amputations: protocol for a randomised feasibility study (the STEPFORWARD study); 2018-2020, National Institute of Health Research.
- €473,406.00: Nicholls et al. Understanding and promoting Whistle-blowiNg on DOPing irregularities in the EU (Win-Dop); 2020-2021; European Commission: Education, Audiovisual and Culture Executive Agency [Unit A.6, Erasmus +: Sport, Youth and EU Aid Volunteers].

Figure 2 UoA24 Research Income Spend (2008/9 to 2019/20)



Of note has been the success in winning competitive funding of over £1.0 million (March 2014 to January 2020) for anti-doping research conducted at Hull, led by **Nicholls A**. Other smaller grant spend within the period (up to £20 K), includes those associated with research projects from a variety of representative and regulatory sporting organisations, including Federation International Football Association (FIFA), International Olympic Committee (IOC), International Tennis Federation, Sport England, and Sports Coach UK. Local collaborations with competitive sporting teams include Hull City Tigers Ltd. and the Hull Kingston Rovers partnership. Led by **Abt**, there has been continued research income from local professional soccer (approx. £163 K) and rugby league (£15 K) organisations which have been utilised to create a series of departmental PhD/MSc studentships and improve research infrastructure for sport science support for these local sporting teams. **Abt** has also obtained funding to support various innovations in the application of mobile monitoring technology applied to both the sporting and healthcare fields. **McClaren-Towilson** has received funding (£15K) from the Union of European Football Association (UEFA) Research Grant Programme; for bio-banding as a tool for identifying talented academy soccer players. Research funding for specific health-related research projects has come from local government (East Riding of Yorkshire Council), local pharmaceutical companies (Reckitt Benkiser Healthcare) commercial / industrial projects (with City Health Care Partnership, Hull) and national (Iliostomy Association) and regional health charities, including Help for Health, East Riding Cardiac Trust Fund and Osprey. **Ingle, Carroll, Nicholls** collaborate (Chetter and colleagues) on the INITIATE study with funding provided by the NIHR. **Ingle** and **Carroll** secured the PDRA post (Nichols, S) part-funded by the NHS City Healthcare Partnership. **Vince** and **Marshall** have obtained funding from the East Riding of Yorkshire Clinical Commissioning Group for exercise interventions.

UoA24 staff have made an increasingly important contribution to numerous prestigious University-wide external research income awards and projects (NIHR), including Academic Cardiology and Academic Vascular Surgery, Rehabilitation Medicine (within HYMS and HUTH NHS Trust). The research income of these projects has been captured with the Allied Health (UoA03) submission of the UoH.

The UoA24 staff and PGR students have access to dedicated human research laboratories with breath-by-breath, laboratory metabolic gas analysers (including several Oxycon Pro metabolic cart (Jaeger) and other portable metabolic devices. There are extensive exercise testing ergometers,

including Woodway and other treadmills, a range of electronically driven cycle and rowing ergometers. Other dedicated units in the Washburn building laboratories, include integrated Case 12-lead ECG/ Treadmill (GE Healthcare), Vivid ultrasound (GE Healthcare), including 2D, M-mode, pulse wave Doppler echocardiography, ECG-gated automated blood pressure devices (Tango, SunTech Medical) and Innocor® metabolic cart with expired gas re-breathing facilities. Our validation (Nichols, S et al. *Clin Physiol Funct Imaging* 2016) of the Cardiohealthstation® by novice operators allows the reliable, rapid early detection of atherosclerotic vascular disease (Panasonic Biomedical).

UoA24 staff and PGR's have also made extensive use of laboratories across the HUTH NHS Trust for cardiopulmonary evaluation and exercise testing in clinical groups. These includes the cardiorespiratory laboratories of the Daisy Research Building (Castle Hill Hospital, Hull) and the exercise testing laboratory at the Vascular Unit, Hull Royal Infirmary. These collaborations and facilities allow medical supervision of testing in higher risk participants. Facilities at the vascular laboratory, Hull Royal Infirmary, include an integrated motorised treadmill and cycle ergometer with metabolic cart (MedGraphics Ultima™ CardioO₂; Medical Graphics) and 12-lead electrocardiogram with automated analysis (Mortara mobile system; Medical Graphics). The Daisy Building also allows access to more advanced body composition analysis equipment using dual energy X-ray absorptometry [DEXA] (Lunar iDXA, GE Healthcare). The Daisy Charity has significantly improved research and treatment facilities for people in the Hull & East Yorkshire region since completion of the scientific laboratory facilities, a clinical trials unit, teaching accommodation. In 2004 the Jack Brignall PET-CT Scanning Centre was opened to complement the research base, both facilities totalling £12.5M are on the Castle Hill Hospital site. The final component of the state-of-the-art imaging infrastructure will be the opening of a Positron Emission Tomography research Centre (PETRC), comprising radiochemistry and cyclotron units capable of producing radioactive tracers (led by Prof Archibald and clinical advisors). This £8.2M facility offers a unique research base in the North-East of England. **Hobkirk** and **Carroll** are commencing studies on cardiac metabolism (with Archibald and Trust cardiologists) with innovative tracer research to benefit patients with cardiovascular disease).

Collaboration and contribution to the research base, economy and society

As exemplified in Figure 1, the vast majority of UoA24 research has an external impact both in terms of collaborations and the outputs themselves. The following section will take each sector in turn and the impact that Hull makes will be described.

Summary of contribution to journals and grant review:

Overall, UoA24 staff have published over 200 separate peer-reviewed scientific publications in the period 2014-2020 with multiple contributions to some of the higher impact factor journals across different medical and scientific specialties (*BMJ Open* [x3]; *Heart*; *International Journal of Cardiology*; *J Vascular Surgery* [x3]; *PLOS One* [x4]) and sport and exercise science-related journals; including, *British J Sports Medicine* [x3]; *Frontiers in Physiology* [x2]; *Frontiers in Psychology* [x3]; *Medicine and Science in Sports and Exercise* [x4]; *International Journal of Sports Medicine* [x2]; *Gait and Posture* [x5]; *J. Sports Science* [x3]; *Int. J. Sports Physiol and Performance* [x3]; *J. of Strength and Conditioning Research* [x6], amongst others.

The staff submitted in UoA24 contribute significantly to a breadth of editorial boards; these include; *Frontiers in Psychology*, *Research in Sports Medicine*, *Open Heart Failure Journal*, *Case Studies in Cardiology*, *Journal of Sports Science*, *Journal of Strength and Conditioning*.

UoA staff are heavily involved serving on grant panels, current examples include a range of national and international grant awarding bodies, including the Medical Research Council, British Heart Foundation; World Anti-Doping Agency; Biotechnology and Biological Sciences Research Council, Engineering and Physical Sciences Research Council, National Institute for Health Research Programme Grants (Applied Research and for Patient Benefit). Likewise, staff have

peer-reviewed extensively for journals across their respective disciplinary areas (for example *Brit. J. Sport Med.*, *J. Appl. Physiol.*, *J. Physiol.*, *Med. Sci. Sports Exerc.*, *Journal of Sports Sciences*, *Journal of Science and Medicine in Sport*, *International Journal of Sport and Exercise Psychology*, *Gait and Posture*, *Frontiers in Psychology*).

National and international awards/positions of esteem for UoA24 staff, include the following;

- **Abt** is now a BASES Fellow and Executive Editor of the *Journal of Sports Sciences*.
- **Nicholls** is Associate Editor *Frontiers in Psychology*.
- **Vanicek** is an honorary associate of the BAGPAR scientific group on guidelines development for amputee rehabilitation, and Associate Editor of the *Journal of Sports Sciences*.
- **Ingle** is fellow of the European Society of Cardiology.
- **Carroll** served as President of the Lipid, Metabolism and Vascular Risk section of the Royal Society of Medicine (RSM), London (2017-2019).
- **Carroll** and **Hobkirk** are Council members of the newly formed RSM section; Vascular, Lipid and Metabolic Medicine.
- **McLaren-Towilson**; a UEFA Research Committee Member.

Nicholls (and Cope) lead a substantial international project funded by the European Commission and others in the area of anti-doping in sports. In collaboration with six international organisations, Nicholls led a systematic review, which informed the development and testing of the ADVICE anti-doping mobile application for coaches. **Nicholls** (and former colleague Perry) developed an appropriate framework for understanding the factors that predict doping attitudes among young athletes, called the Sport Drug Control Model for Adolescent Athletes (SDCM-AA), which identified new psycho-social factors that influence attitudes towards doping among adolescent athletes. Funded by WADA, Nicholls (with Perry, PDRA Thompson) then used the SDCM-AA to create and validate the Athlete Sports Doping Inventory (ASDI) among athletes from 4 continents (Nicholls et al. *Psychological Assessment* 2019). The purpose of this app is to increase knowledge and reduce favorable attitudes towards doping among grassroots coaches working with young athletes. To date, the ADVICE app was tested in seven different languages, including Russian. **Nicholls**, **Abt**, developed and evaluated the iPlayClean anti-doping education programme for young athletes on a talent pathway programme within the UK, within a clustered randomised controlled study. The ASDI, has been adopted by the World Antidoping Agency (WADA), which recommends that national anti-doping organisations and academics use the ASDI to screen athletes and assign them to empirical “susceptibility” groups. More details of the wider impact are highlighted in the anti-doping impact case study.

Funded by the NIHR (Research for Patient Benefit (£249 K), **Vanicek** as Chief Investigator, developed a body of research underpinning the feasibility for a large-scale trial (the STEPFORWARD study) investigating the effectiveness (patient benefit and cost implications) of a novel prosthesis compared to standard treatment for older patients with vascular-related amputations. The multi-centre RCT trial has involved a multi-disciplinary group of researchers, healthcare providers (consultants, prosthetists, physiotherapists) and patient public members nationally to deliver successfully on an underdeveloped area of healthcare (Mitchell et al. *British Medical Journal Open [BMJ Open]* 2019). From 2006-2010, **Vanicek** and colleagues progressed a framework for identifying biomechanical factors that distinguished amputee fallers from non-fallers. As a direct result, evidence-based recommendations for falls prevention through exercise were established. **Vanicek** and **King** have collaborated extensively with the Academic Vascular Surgery Unit, Hull Royal Infirmary (Chetter and colleagues) on functional capacity, gait and posture (and the effects of exercise interventions) in patients with peripheral arterial disease (8 published outputs, 2014-20), including important insights into dynamic muscle/tendon characteristics and walking ability. Ongoing work on the altered biomechanics and gait in older postmenopausal females with osteoporosis (with Medical and Biological Engineering, UoH) is developing new concepts of musculoskeletal function. **Vanicek** also contributes to the ongoing work of the 1000 Norms Project Consortium (University of Sydney, Australia) providing an

accessible database of musculoskeletal and neurological reference values representative of the healthy population across the lifespan (McKay et al. *Neurology* 2017).

The ongoing work of **Ingle and Carroll** examining the role of maximal cardiopulmonary exercise testing and exercise training in the secondary prevention of cardiovascular disorders and cardiac heart failure retains strong links with both Academic Cardiology (Lifelab database, HYMS) and the Academic Vascular Surgery Unit. Over the last 5-6 years, extensive high-quality research outputs (published in the *European Heart, Preventive Cardiology, and Heart Failure journals*) have focusing on patients with cardiovascular disorders, especially coronary heart disease (CHD) and chronic heart failure (CHF). Several outputs feature risk stratification and prognostication using cardiopulmonary exercise testing (CPET) and have been cited within contemporary scientific statements, notably those of the American Heart Association and European Society of Cardiology. In conjunction with Academic Cardiology, **Ingle and Hobkirk** led a British Heart Foundation funded study on the experiences and laboratory modelling of air travel in patients with CHF. This work has since been incorporated within expert medical committee guidelines on air travel. **Carroll, Ingle** and collaborators have provided observational evidence that open-ended, supervised community-based, cardiac rehabilitation improves submaximal fitness measures, which are strongly associated with reduced long-term (up to 20 years) all-cause mortality (the “HeartWatch” programme’, with Leeds City Council and Witte, Leeds Teaching Hospitals Trust). **Ingle and Carroll** obtained funding from the City Healthcare Partnership, Hull for PDRA Nichols to undertake the CARE-CR study - delivered in co-operation with Academic Cardiology (Nichols et al. *BMJ Open* 2018). Importantly this controlled evaluation of community-based NHS cardiac rehabilitation, illustrated some of the challenges in improving gold-standard cardiorespiratory fitness outcomes and secondary risk markers in routine practice (Nichols et al. *International J Cardiology* 2020). This project has already delivered numerous research papers, including those relating to the most appropriate modelling/scaling of exertional physiological measures to whole body/ appendicular muscle mass. Outputs have received repeated readership awards (*Clinical Physiology and Functional Imaging*, Elsevier). Following on from the above cited study, **Ingle** and colleagues are now undertaking the largest prospective, multi-centre, randomised trial of high-intensity interval training (HIIT) within NHS cardiac rehabilitation (McGregor et al. *BMJ Open* 2016; *HIITT or MISS UK* study), integrating an economic analysis of HIIT compared with usual care exercise rehabilitation.

Ingle and Carroll also worked closely with the Vascular Surgery Unit to develop and implement the INITIATE study, a novel, prospective interventional study of HIT in patients with peripheral vascular disease (PVD) and intermittent claudication (NIHR funded). **Carroll and King** continue to work with vascular unit and wider international partners (Harwood and Parmenter, Sydney, Australia) within exercise testing and training within PVD, including abdominal aortic aneurisms. **Ingle** and colleagues have produced a BASES expert statement and related Infographic (Tew et al. *Brit J Sports Med* 2020) on exercise training in PVD and a Cochrane Library systematic review considering lower limb pre-surgical “prehabilitation”.

Carroll, Ingle, King, Marshall, Vanicek and **Vince** have continued to oversee and publish the findings of numerous clinical and community-based exercise training interventions, including those undertaken in premenopausal obese females (with Marshall & Tan, Universities of Leeds Teaching Hospitals NHS Trust and Borkoles, Australia), polycystic ovarian syndrome and postprandial lipemia in overweight/obese females (with Atkin, Aye, Sathyapalan; HYMS), PVD patients with intermittent claudication (Chetter, HYMS). Cross-sectional observational studies, including large multi-disciplinary collaborative projects in healthy adults (**Carroll, Ingle** with Swainson, Lancaster & Nuffield Health and Wellbeing PLC, Manchester) and **Vince** (with the Academic Endocrinology, and Atkin, now Weill Cornell, Qatar) have increasingly focused on cardio-metabolic risk (including various, inflammatory and vascular/endothelial stress responses to exercise training) within females with diagnosed with polycystic ovarian syndrome. Using sophisticated, dynamic lipid-infusion techniques and criterion measures of muscle insulin sensitivity this group have provided important insights some of the fundamental mechanisms underlying insulin resistance (Aye et al. *Frontiers in Endocrinology* 2018) /endothelial function and changes associated with exercise training in these patients. Other aspects show improvements in

adipose tissue functionality with PCOS treatment (**Carroll, Hobkirk**), or strength and functional outcomes in severe obesity states (**Marshall, Vince**).

Vince and **Marshall** have collaborated with Academic surgery/Gastroenterology Research (MacFie, HYMS) in acute cancer diagnostic settings and reported on the feasibility and complexities of delivering a functional, exercise-based “prehabilitation” interventions and its effects on postoperative outcomes in elective colorectal surgery patients. **Hobkirk’s** (with **Carroll**) collaboration on lipid research within paediatric obesity on exercise interventions and lipoprotein-lipid biochemistry and metabolic risk (together with Gately and colleagues Leeds Beckett), has been extended by recent collaboration with Reuter (Santa Cruz do Sol, Brazil) investigating paediatric lifestyle and metabolic, vascular risk and associated genetic polymorphisms in larger epidemiological studies of southern Brazilian children. **Hobkirk** and **Carroll** (with Hesselink, Maastricht, Netherlands), are examining aspects of the fatty heart and associated metabolic abnormalities in patients undergoing coronary bypass grafting (with Loubani, HYMS), with particular emphasis on longer term risks of heart failure/mortality associated with diabetes (and benefits of post-CABG interventions).

ECR, **Simpson** has a rapidly developing international profile in the diagnosis and treatment of exercise-induced asthma (EIA) and related conditions. Working with other sports science experts (Romer, Kippelen, Brunel, London) **Simpson** has produced influential work on self-reported symptoms on induced and inhibited broncho-restriction in athletes, the effects of exercised - induced dehydration/creatinine supplementation, also the effects of standard treatments on underlying pathogenic mechanisms of EIA. He has also formed excellent collaborations with pre-eminent clinicians (Fowler, Manchester), including asthma self-management within mobile health applications (European U-BIOPRED Adult Asthma Cohort; EC 7th Framework Programme).

Work on physical activity monitoring using wearable technology is the focus of the Personal Technologies research group (led by **Abt**), including collaborators from Australia and Spain. The group have examined the fundamental measurement properties of the world’s most popular physical activity tracker, the Apple Watch. Investigations have focused on the accuracy of the heart rate sensor, its ability to quantify moderate-to-vigorous physical activity, and its use during cardiac rehabilitation classes.

With implications for player monitoring, talent identification and position selection in elite youth soccer, ERC **McClaren-Towlson** has conducted large scale cross-sectional investigations studying relative age, maturation effects on anthropometric /physical fitness, selection and position allocation within elite youth. This work includes the (UEFA) Research Grant Programme for “Bio-banding” as a tool for identifying talented academy soccer players. **Abt**, and colleagues continue with their extensive research outputs on innovative methodologies (and commercial applications) for monitoring sporting training and competition loads within elite team sports (with Weaving, Till & Jones, Leeds Beckett), including individualisation of time-motion analysis, player-tracking and the monitoring internal and external-training load measures. **Marshall** and colleagues have investigated different aspects of resisted exercise and complex training on muscular post-activation potential in elite sportsmen and the application of resistance exercise within home-based clinical exercise programmes.

Systematic reviews and meta-analyses of published studies, especially RCT’s, are widely regarded as comprising the highest level of scientific evidence. Building on existing UoA strengths with this methodological approach, 6 current (2 former) UoA24 staff have contributed to 13 published systematic reviews/meta-analyses, including those detailed below (not included amongst UoA24 submitted outputs);

- Presurgery exercise-based conditioning interventions (pre-habilitation) in adults undergoing lower limb surgery for peripheral arterial disease (*Cochrane Database Syst Rev.* 2020; **Ingle**).
- Structured exercise training following Traumatic Brain Injury (*Brain Injury* 2020; **Carroll, King, Vanicek**)

- Robot assisted gait training for people with spinal cord injuries (*J Spinal Cord Med*, 2018; **Vanicek**).
- Muscle morphology and function in patients with intermittent claudication (*J Vasc Surg*. 2017; **King, Vanicek**).
- Resistance training on strength and physical function in overweight/obese adults (*J of Physiotherapy* 2020; **Vince**).
- High-intensity training for intermittent claudication (*J Vasc Surg*. 2019; **Ingle**)
- Home-based exercise programmes for individuals with intermittent claudication (*SAGE Open Med*. 2018; **Ingle**).

The previously outlined UoA research strategy (RAE2014) incorporated a developmental internationalisation agenda. Subsequently, the international standing of the group has continued with numerous invited oral and keynote presentations having been undertaken at international meetings, including UEFA Research Programme; World Congress of Science and Football; European College of Sport Science; The Sixth International Conference of Ministers and Senior Officials Responsible for Physical Culture; The Association for International Sport for All World Congress; Sport Science Summit, UK; USA National Coaching Conference; England Athletics Annual Conference; British Psychological Society, Royal Society of Medicine, UK; and for research groups within numerous universities (including, Sanger Institute, University of Cambridge, UK; State University of Rio de Janeiro, Brazil; Universities of New South Wales & Sydney, Australia). Staff are also collaborating with the following bodies on research projects, British Association for Cardiovascular Rehabilitation and Prevention; International Council of Sport Science and Physical Education (Germany); The Association for International Sport for All, KEA Sport (Greece); National Anti-Doping Agencies of Spain, France, Austria, Denmark.

Staff have examined PhD candidates for the following Universities within the period; Bradford, Buckinghamshire, Edge Hill, Essex, Greenwich, Huddersfield, Leeds, Leeds Metropolitan, Liverpool JMU, Loughborough, Manchester, Salford, Wolverhampton, and internationally at Santa Cruz do Sol (Brazil), Sydney (Australia), Australian Catholic University (Australia), University of Western Australia (Australia), Otago (New Zealand), Laval (Canada) and University of the South Pacific.